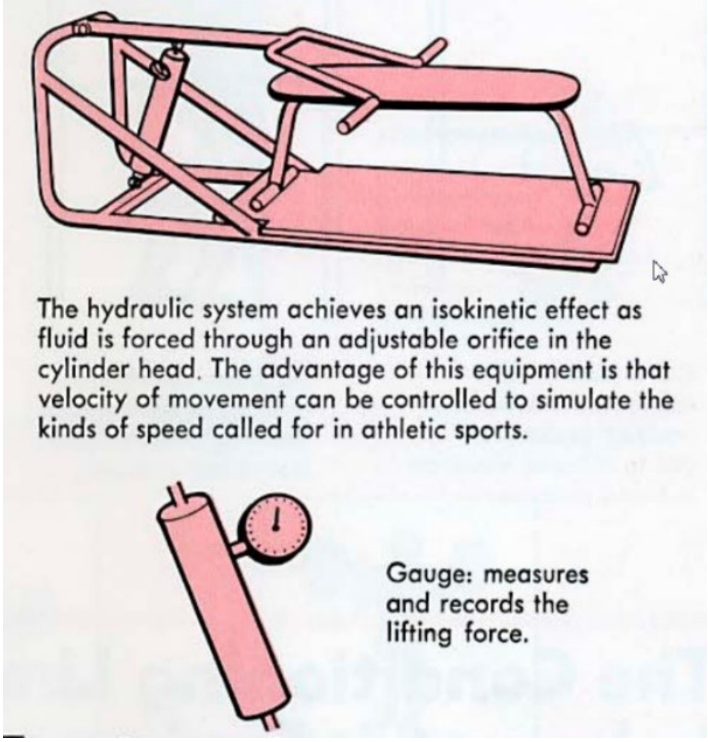
Chapter 14: The Ariel Computerized Exercise System

I have discussed previously my association with the Universal Gym exercise company. I was involved with them for about eight years and helped to design the most advanced exercise system of the time. However, the designs were for equipment constructed of metal, utilizing cams to provide resistance which varied throughout the exercise movement. These were appropriate types of exercise equipment for a gym, school, or athletic setting since they could be used by many people continuously all day long. Many of the people who trained on this type of equipment were young and, frequently, insensitive or uncaring about the wear and tear on the systems. For this reason, the equipment had to be rugged and able to sustain the stress and abuse of the exercising public. The Universal Gym equipment was designed specifically for this marketplace and the type of exercise users who, in general, were indelicate when working out on the equipment.

For its time and place in the world of exercise, the Universal Gym equipment, which employed the dynamic variable resistance (DVR) system, was the best training de-

The Universal Gym Equipment with DVR (Dynamic Variable Resistance)
http://arielnet.com/ref/go/1182



The hydraulic system achieves an isokinetic effect as fluid is forced through an adjustable orifice in the cylinder head. The advantage of this equipment is that velocity of movement can be controlled to simulate the kinds of speed called for in athletic sports.

Gauge: measures and records the lifting force.

The Universal Hydraulic Machine
http://arielnet.com/ref/go/7001

vice available. However, there were some limitations even for this advanced system. For one thing, the cam provided only a fixed pattern of adjustment. However, anyone who wanted to change the form of the exercise was unable to make any alteration. It was impossible to swap different cam shapes into and out of the equipment in order to follow a different movement path. Another limitation was the inability to accelerate at the end of the exercise movement due to the rigidity and inflexibility of the hardware. An isometric contraction imposed at the midpoint of the exercise was impossible since a cam cannot provide this option.

The Universal DVR machines were fantastic exercise devices for the 1970s and continue to provide superb exercise into the 21st century. But I was convinced that there could be better and smarter machines which would provide improved exercise benefits. I had not discovered anything, but in my mind, I was confident that I could create something that would fill the void. I concluded that I would have to invent something. Ever the optimist and with dogged determination, I pondered and considered a number of ideas that might work.

One possibility which I considered was to use air in closed cylinders to provide resistance. However, there were problems with using air:

1. Air would have to be provided to each unit.
2. The amount of pressure could not be regulated or calibrated.
3. The system would have to be pressurized at all times.
4. Pressurizing the system would require electrical connections.
5. Air can only be compressed.

What if there were leaks in the cylinders or the pressurized lines which delivered the air? What would happen during an electrical failure? How would you provide for each movement direction? Since air cannot be stretched, there would have to be two cylinders for an exercise such as a biceps flexion/extension exercise or any other bi-directional limb motion.

I reconsidered another proven exercise system that provided increased and decreased forces throughout the movement. These were stretchy devices like the ones I had developed during my brief time at Indiana University in Bloomington, Indiana. When I was a student and the assistant track coach at Indiana University, I had taken several different lengths of surgical tubing from the medical school. I attached handles to one end of the tube and fixed the other end to the wall. These simple tubes provided incredible exercises for three-dimensional joint movements and the more the tube was stretched, the greater the resistance to the muscle. In addition, they were light and easily portable. Unfortunately, they could not be calibrated, so the person exercising had no idea how much force he or she was exerting.

Although I was no longer actively competing in the discus throw, I exercised every day. Anyone who engages in resistive exercise training recognizes the quiet voids that accompany these tasks. During these quiet times, I considered ideas which appeared in my imagination. One day during my normal exercise routine, while I was raising and lowering a barbell in a bicep curl, I considered what I was actually doing during the motion. I observed that it was easy to lift the weight at the beginning of the exercise when my arm was down with the barbell in my hand. However, while lifting the weight up as I bent my elbow, it felt as though the weight had become heavier until after I had passed the halfway point when my elbow formed a ninety-degree angle. Thereafter, as I continued the curl, the weight again seemed to weigh less in my hand as it approached my shoulder. The situation occurred in reverse as I lowered the barbell. I was struck with the sequence of easy, harder, very hard, less hard, and finally easy again for the curl exercise.

I concluded that what I really needed was a little magic genie to add and remove weight from the barbell throughout the exercise. I imagined that this little magic genie could add weight, incrementally, when it was easy for me and remove weights when I struggled to raise the bar. In other words, the genie could add or remove some of the load during the exercise so that the load adjustments would be fine-tuned to the person performing the exercise. My eureka moment occurred as I realized that I needed the exercise device to adjust to the person rather than the person having to adjust to the equipment.

These thoughts whirled around in my head. I had long ago recognized the limitations of traditional equipment. Perhaps my new "magic genie" revelation could provide a better way to exercise. I recognized that I would have to find a way to make the equipment smart enough to adapt to the individual. This would take more time and thought to solve. The solution I imagined would adjust or respond to the continuous changes between levers (bones) and the load so that an exercise could be optimized for that individual. This mechanism for changes would need a method for regulating and recording these adjustments. I needed to invent a system with a brain.

Then and now, traditional resistive training equipment are merely simple tools which lack intelligence. This type of equipment has no "awareness" that a subject performs an exercise on it. The human brain can sense touch, see objects in motion, determine smells, tastes, and sounds and act according to the sensory inputs. No exercise hardware could function like a human because none has brains. How could I give an exercise device this thinking capability?

My initial thoughts led me to the consideration of the human body's use of closed loop feedback and sensory capabilities. This neurological and muscular system provides people with the ability to execute large and fine motor skills. Many controls are at a subconscious level such as breathing, walking across the room, and chewing food. Other tasks necessitate greater cerebral attention such as running down a runway for the pole vault in track and field, or manipulating the dials on an electronic device. These sophisticated neurological control capabilities did not exist on any fitness training equipment.

However, as I pondered the idea of an exercise machine that could have a brain and closed loop feedback abilities, I naturally turned to the newly developing world of computers. With the advent of miniaturized electronics in computers, perhaps it would be possible to connect an exercise device to the computer's artificial intelligence. If I could find a way to combine hardware with computerized software, then the equipment could adjust and adapt to the exerciser. This would be the ultimate exercise device—one with a brain. Now, the task was to create this smart exercise system. It seemed like a straight-forward concept, but I had no idea how long and arduous the path to success would be.

I thought about what currently existed among the many exercise devices available. I had previously rejected air, springs, and stretchy surgical tubing, since they were difficult to control. Then I remembered a small hydraulic exercise system that we had in our Amherst office which was a prototype for a Universal Gym Equipment product idea. Ed Burke, the American Olympian hammer thrower, and I worked on this Universal machine a number of years ago. The project had been canceled but the hardware was stored in the back of our office.

Ann and I pulled the cobweb-covered machine into the middle of the room. We cleaned it off and then examined the structure and component parts. The exercise bar and handles were fixed to a small post. Also attached to the post was a small hydraulic cylinder with a small handle for opening and closing the valve. We turned the handle to open the hydraulic cylinder valve and then moved the bar up and down. The movement was relatively smooth and it was easy to move the valve control dial. However, when I closed the valve on the cylinder, as the bar was raised or lower, it was more difficult to move the bar.

"This is perfect for beginning the exercise machine with a 'brain'", I exclaimed in a surprised and happy manner while Ann smiled in her understandingly, supportive way. Hydraulic cylinders have valves that can be regulated. In addition, the materials are easy and inexpensive to acquire and the oil can be anything from hydraulic fluid to maple syrup! The oil can be contained, cylinders valves can be regulated, and these components can be controlled with computer software. My brain was on fire with ideas. I felt as though there were fireworks exploding out into the room around me but, as I looked around the office, everyone was working quietly and normally.

I was always enthusiastic about new ideas so naturally I wanted the world to know about this concept. In 1975, I submitted an abstract for "Computerized Dynamic Resistive Exercise" which I subsequently presented in 1976 at the International Conference of the Montreal Olympics in

Birth of the concept for the Computerized Exercise Machine
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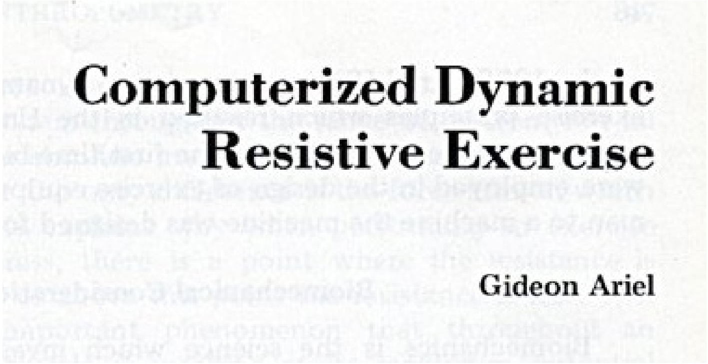

Computerized Dynamic Resistive Exercise

Gideon Ariel

Alan Blitzblau, demonstrating the first motion capture program created at CBA in 1972
http://arielnet.com/ref/go/1184

Canada. Now, my goal was to transform this idea into a tangible system.

I called a staff meeting to consider my ideas with regard to actually implementing them. At that time, one of our programmers, Alan Blitzblau, was a genius with software programs. Independently, Ann and I had met Alan when he was working in the Computer Science Department. We each had sought his help at the computer center and had become quite friendly.

Ann had needed Alan's help with some programs related to her doctoral research. Since she was a typical graduate student surviving on pittance, she "paid" Alan for his assistance by baking pecan pies for him. In fact, he named her computer program "Pecan Pie".

The three of us frequently had lunch together at a local sandwich shop where Alan and I would play one of the first video games, "Pac-Man". After CBA moved the office from Dartmouth College to Amherst and grew large enough to need a full-time, in-house programmer, we had hired Alan.

Alan agreed that the idea of programming a computer to control an exercise machine was fantastic and clearly a problem that we could solve together. Alan had worked with two students in the engineering department, Justin Milliun and Peter Smart, who had complementary talents with regard to electronic controls and computer systems. He contacted them and brought them to our office so I could explain my idea. Alan was confident that he, Peter, and Justin would be able to program the computer, hardwire any components onto computer control boards, and interface all.

At that time, the only computers commonly available were the large mainframe computers, such as the Honeywell at Dartmouth College and Control Data at the University of Massachusetts. These systems were powerful and could handle many users simultaneously and could easily handle the computerized exercise device that I envisioned. However,

Original concept of the computer-controlled exercise machine
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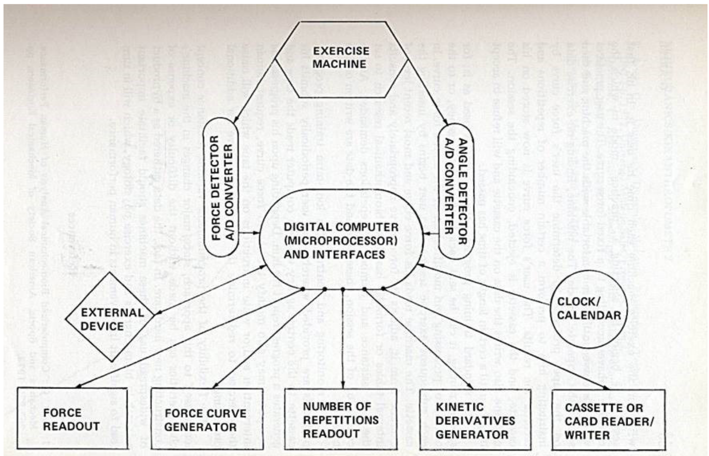

Fig. 1. The programmable variable resistance exerciser flow chart.

Justin Milliun

Peter Smart

these monsters filled hundreds of feet of floor space, required massive amounts of electricity and cooling, and needed large staffs for operational management. Clearly, these were inappropriate computer options for our need.

Fortunately, the world of computers was about to explode into an entirely new and vast experience. In one of our first meetings with Peter and Justin, we were introduced to an exciting adventure in electronics. Peter and Justin described a single chip microprocessor which had been introduced in late 1971 by a company called Intel. This revolutionary microprocessor was the size of a little fingernail yet could deliver the same computing power as the first electronic computer built in 1946 which had filled an entire room. In 1971, the Intel 4004 processor held 2300 transistors and was produced on two-inch wafers. The Intel 4004 microprocessor was unique in that it was one of the smallest microprocessor designs that ever went into commercial production. After the invention of integrated circuits which revolutionized computer design, the next step was to make things smaller. The Intel 4004 chip moved the integrated circuit down another step by placing all the parts that allowed the computer to think, i.e. central processing unit, memory, input and output controls, onto one small chip. Fortunately, for CBA and my quest for an exercise machine with brains, this Intel microprocessor appeared to be the miracle solution for our needs. We needed computing power that did not fill half of a university building and this little tiny electronic wafer seemed to be exactly what was required.

Intel 4004 microprocessor in 1974
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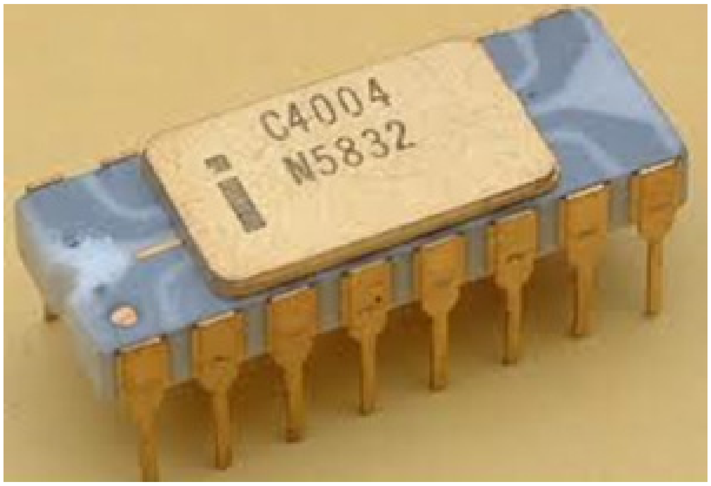
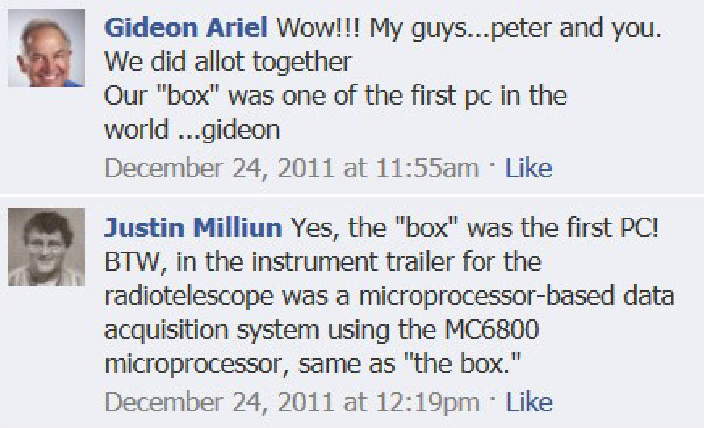


Alan explained that Justin was knowledgeable in the assembly language required to program the Intel chip. Alan and Justin would be able to design the flow of information between the various components and the microprocessor. Peter's contribution was to design and build the circuits to connect all of the interfacing components of the exercise machine's brain, sensors, and control devices.



Gideon Ariel Wow!!! My guys...peter and you.
We did allot together
Our "box" was one of the first pc in the world ...gideon
December 24, 2011 at 11:55am · Like

Justin Milliun Yes, the "box" was the first PC! BTW, in the instrument trailer for the radiotelescope was a microprocessor-based data acquisition system using the MC6800 microprocessor, same as "the box."
December 24, 2011 at 12:19pm · Like

Justin Milliun and Peter Smart prepare the antenna to pick up radiation bursts from Jupiter.

Justin and Peter designed for me the first personal computer before Apple or Atari and way before the IBM personal computer. See above for correspondence between Justin and myself recently on Facebook:

We also were fortunate that Justin and Peter knew a professor at the university that they believed could be an asset to the project. They had worked with him on various university projects and had taken several classes from him. Ann and I decided that it was a good idea to meet the fellow and perhaps good things could result. We told them to have him come to the office.

Dr. Jeremy Wise at NASA Shuttle Project

A day or two later, Ann and I were working in our front office and noticed a skinny fellow with a huge head of hair and a beard staring up at the sign above our office door. The behavior of staring at our sign with a puzzled expression was a common experience for us. However, this man had more of a hippy appearance than those we normally saw. Imagine our surprise, when the fellow opened the door and introduced himself as Justin and Peter's professor. His name was Dr. Jeremy Wise. "Wow", I thought to myself, now we would have "smart" and "wise" in our office!

He had a quiet, confident demeanor but the longer we chatted, the more we realized that he possessed an incredible knowledge base. Dr. Wise had received his baccalaureate degree in physics from Cornell and his Ph.D. in high-energy physics from the University of Massachusetts. He had taught

Original design idea for the Computerized Exercise System (CES)
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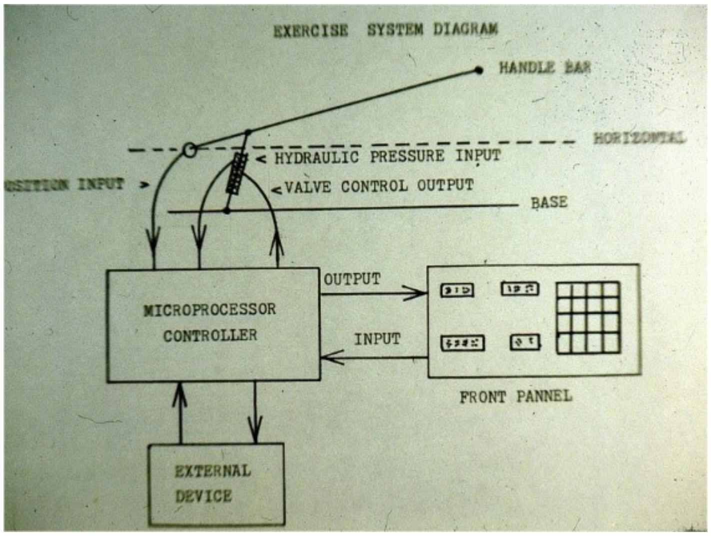


Data General Nova 3
http://arielnet.com/ref/go/1185

math to high school students in New York before moving to Amherst and beginning his Ph.D. studies. His doctoral thesis had involved work on the particle accelerator at the Brookhaven National Laboratory on Long Island in New York. Currently, he was teaching classes in physics at the University of Massachusetts which was where he had met Peter and Justin

I was extremely impressed with his credentials but wondered how we could successfully utilize his many skills and knowledge. I inquired about his computer programming skills and received a modest response. One of the reasons that Peter and Justin had thought Dr. Wise would be an asset to our project was his experience in programming the NOVA computer which was the same as the one in our CBA office.

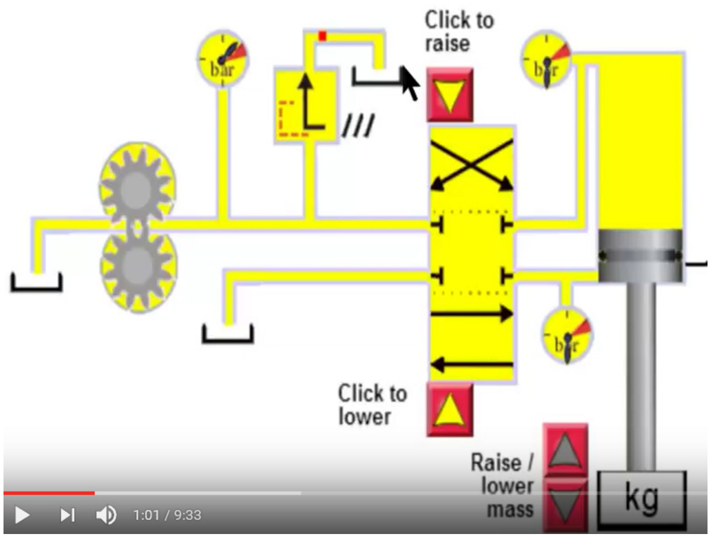
Dr. Wise suggested that we give him a project and then we could determine whether we had things in common. I proposed that he program the stock market. His answer was merely to inquire what and how much I wanted such as daily or weekly listings, all of the stocks or only what I owned, and similar questions. After we had discussed the details, I assured him that I would pay for his hours and then he left the office. I looked at Ann and we both shrugged our shoulders. Neither of us was very optimistic that we would see him again. At that time, in the 1970s, there were no computerized programs within or outside of the stock exchanges. The task we had assigned to Dr. Wise was not only potentially huge but was completely unheard of at that time.

Imagine our surprise when Dr. Wise returned in two days apologizing for the delay. He had to teach his class the preceding day, so he had needed an extra day to complete the programming. He showed us a computer printout of the data that his program had produced on his system.

DR. GIDEON ARIEL demonstrates how the computerized exercise machine his Computerized Biomechanical Analysis firm of Amherst designed, with computer operating hydraulic piston to provide the same resistance as weights used on traditional exercise machines. (Richard Carpenter Photo).

Computerized Biomechanical Analysis

Then he loaded the data into our Data General NOVA-3 computer. Within half an hour, he had loaded, demonstrated, and explained the entire stock management package that he had programmed. We were so impressed with Dr. Wise's talents we hired him on the spot despite the fact that we did not, as yet, know what tasks to assign to him! That was a sig-



Hydraulic valve
http://arielnet.com/ref/go/2708

nificantly momentous day for CBA as well as for Ann and me. Jeremy has been our programmer, colleague, and friend since that day and, hopefully, far into the future.

The tasks for the CBA staff members were set. Gideon and Ann had to find the best hydraulic cylinder and transducer while the software engineers proceeded with their parts. Immediately, Alan and Justin began to design software flow charts. Peter watched their work until he had sufficient information to begin his hardware designs.

During the early days of the computerization, board building, and discovering, Dr. Wise, Ann and I had set ourselves the task to learn more about hydraulic systems. We had found a hydraulic expert in the university's engineering department.

The professor explained that hydraulic machines use liquid fluid power to do simple work. He had described how a huge earth digging machine could serve as an example. In that type of machine, hydraulic fluid is transmitted throughout the equipment to various hydraulic motors and cylinders which become pressurized according to the resistance present. The fluid is controlled directly or automatically by control valves and is distributed through hoses and tubes. The advantage of hydraulic machinery is that a large amount of power can be transferred through small tubes and flexible hoses. In other words, hydraulic machinery utilizes a pressurized liquid (hydraulic fluid) as the powering medium.

The professor explained that the only way to measure force in a hydraulic cylinder was to utilize a transducer to measure the pressure inside the cylinder. Because oil cannot be compressed, the transducer can measure the forces. The pressure transducer can be located outside of the cylinder in a manner that the oil flow passes through it, in pipes, from the top to the bottom of the cylinder itself. This arrangement would allow the pressure to be measured with a transducer set at a high testing rate. The higher the measurement rate, the more frequently the control valve could be opened or closed.

The first hydraulic control valve which we tried to adapt to our exercise machine was a screw type. This type of valve has to rotate in one direction to open and to rotate in the reverse direction to close the opening through which the oil flows. The valve performed well under slow, controlled bar speeds but it could not respond fast enough for rapid changes. Too much time was needed for the valve to spin to the most extreme positions which caused the movement to be jerky rather than smooth. Another problem was that the pressure did not change in a linear fashion. The lack of linearity made the valve difficult to control. We concluded that we needed a different type of valve which could respond more quickly and linearly.

Ann and I returned to our friendly, helpful professors for assistance. His suggestion was to try a hydraulic spool valve which might be more appropriate for our specific needs. Basically, a hydraulic spool valve is a cylinder inside a sealed case. It usually has valves leading to the pump and the tank on one side and valves leading to one or more hydraulic devices on the other side. Pressure on the oil causes it to flow into the valve from the pump into the hydraulic devices or drain out of them back into a hydraulic storage tank. A controller moves the valve back and forth in its case to slide the spool into different positions. The position of the rotor permits the hydraulic fluid to flow only in one direction to perform a specific task.

Hydraulic spool valves can be used in many ways to perform different functions. One of the most common uses is to drive a pressurized hydraulic piston.

The piston is sealed in a cylinder with a valve on either end with both leading to the spool valve. The spool valve controls the amount of oil flow. The spool valve could respond very quickly to the variation in oil flow which corresponded to the pressure. This seemed to be the ideal solution for our specific needs.

The hydraulic spool valve, the main part in the Computerized Exercise Machine
http://arielnet.com/ref/go/2707

At that time, I was enrolled in the Computer Sciences Department at the University of Massachusetts pursuing a second Ph.D. degree. One of my professors was Dr. Conrad Wogrin who was also the department head of Computer Sciences. In his class covering computer hardware, one of the requirements was to have a project. I asked Dr. Wogrin if I could work on my idea of a Computerized Exercise Equipment and design the hydraulic mechanism that would be controlled by the computer. He agreed. The result of this project is illustrated below.

The exercise machine would have a bar with handles at one end for the person to push or pull. The other end of the bar would be connected to the piston in the sealed hydraulic cylinder. The spool valve, under computer control, would be adjusted to open or close as required by the pressure generated by the person exercising according to the designated computer program. From that point until the oil was returned to the accumulator, it could be controlled simply with the use of various check valves.

The control mechanism for our spool valve was a stepper motor. Peter had located a stepper motor which was the first of its kind from a company called Eastern Devices. This was a newly developed device that was digitally controlled whereas previous hydraulic motors had operated under analog control. Although it was easy for large mainframe computers to control analog devices, it was very complicated to regulate and control an analog motor with the newer microelectronics. The digital stepper motor was a digital electric motor which moved a known finite distance with each pulse of electrical power applied.

Stepper motors effectively have multiple, toothed electromagnets arranged around a central gear-shaped piece of iron. The electromagnets are energized by an external control circuit, such as a micro-controller. To make the motor shaft turn, one electromagnet is given power which causes

Hydraulic assembly with stepper motor from the 70's, still used today
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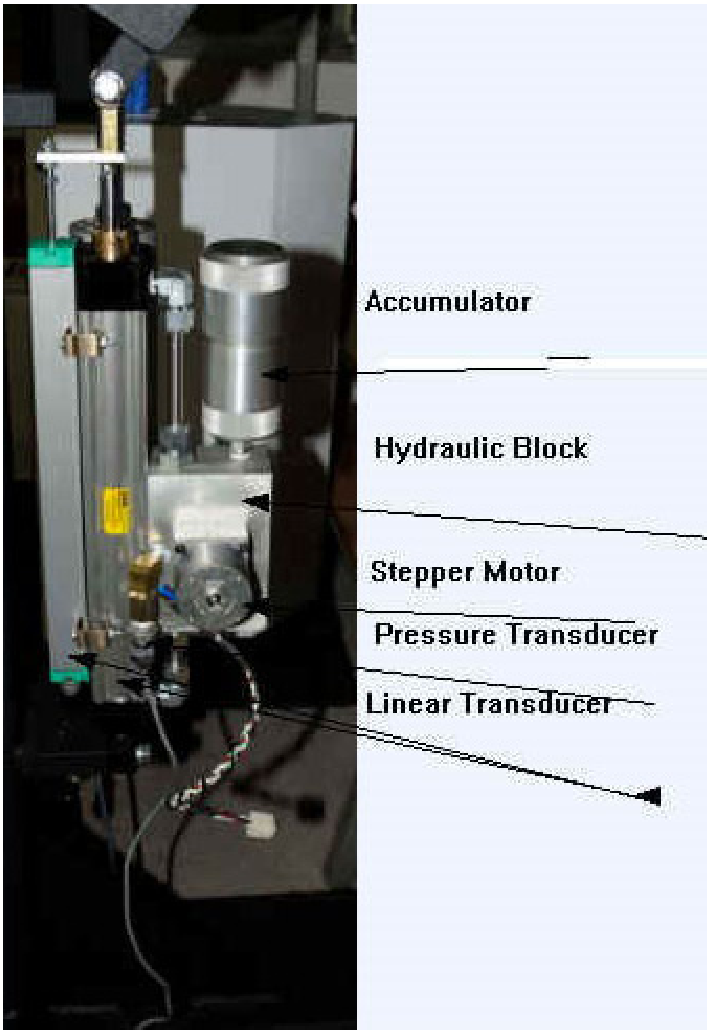
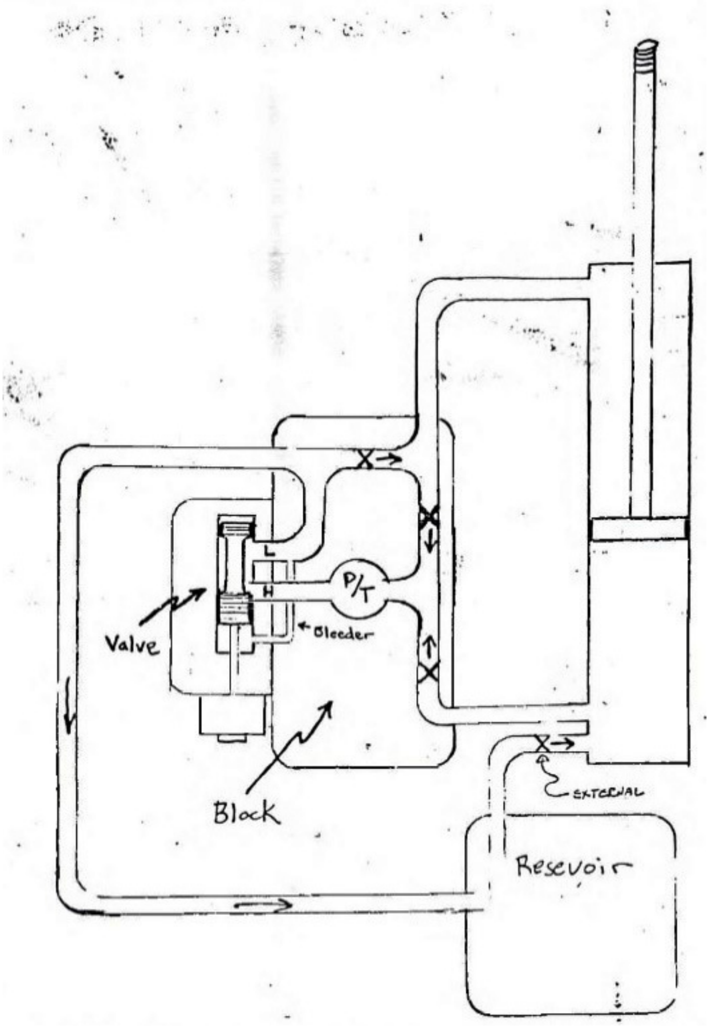


Hydraulic design of the Computerized Exercise Machine in 1973, still in use



the gear's teeth to be magnetically attracted to the electromagnet's teeth. When the gear's teeth are aligned to the first electromagnet, they are slightly offset from the next electromagnet. When the next electromagnet is turned on and the first is turned off, the gear rotates slightly to align with the next one. From that point, the process is repeated. Each of those slight rotations is called a "step" with an integer number of "steps" making a full rotation. In that way, the motor can be turned by a precise angle.

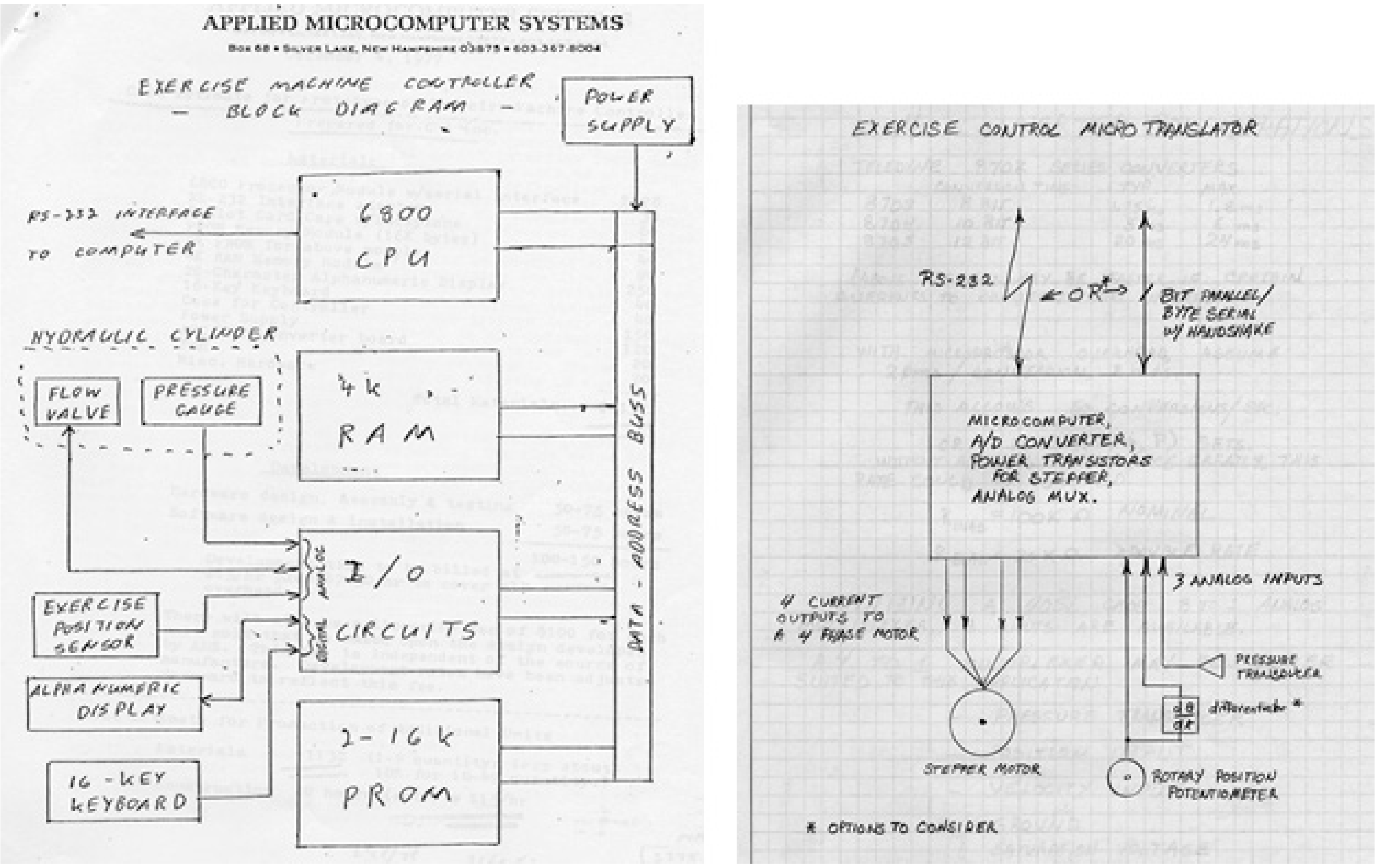
Thus, movement of the spool valve could be easily controlled by electronic signals from a stepper motor. Peter and Justin could control the individual steps of the motor which allowed precise control of the spool valve. The microprocessor software could control the valve and motor so that the exercise bar could provide a person exercising with a smooth bar reaction when it was pushed or pulled.

Electronics control of the valve and stepper motor solved one of our problems. The next problem to solve was to convert the analog data generated by the force and pressure transducers into digital data.

We had two separate measurements, force and position, from the system, which were transmitted to the computer for processing. We could obtain pressure from a transducer located within the hydraulic system and the bar position could be provided by an angular transducer placed on the bar. Electronic circuitry would receive the data from each of the transducers. The problem to overcome was that the signals from each of the transducers were analog rather than digital. In order for the software that Peter and Justin were creating to process and control the system, the transducer signals would have to be converted from analog to digital. In other words, the data had to be transformed into digital data before the "brain" could process them. Following the conversion, that information would be sent to the stepper motor control system to open or close the value.

This is analogous to the sensory-motor feedback loops within the human body and that was the way I described the system to our two engineers. Consider, for example, drinking water from a cup. The hand and arm must lift the cup to the mouth. The position of the arm must be constantly monitored for position and to control the action. The amount of

Flowchart of the Exercise Machine

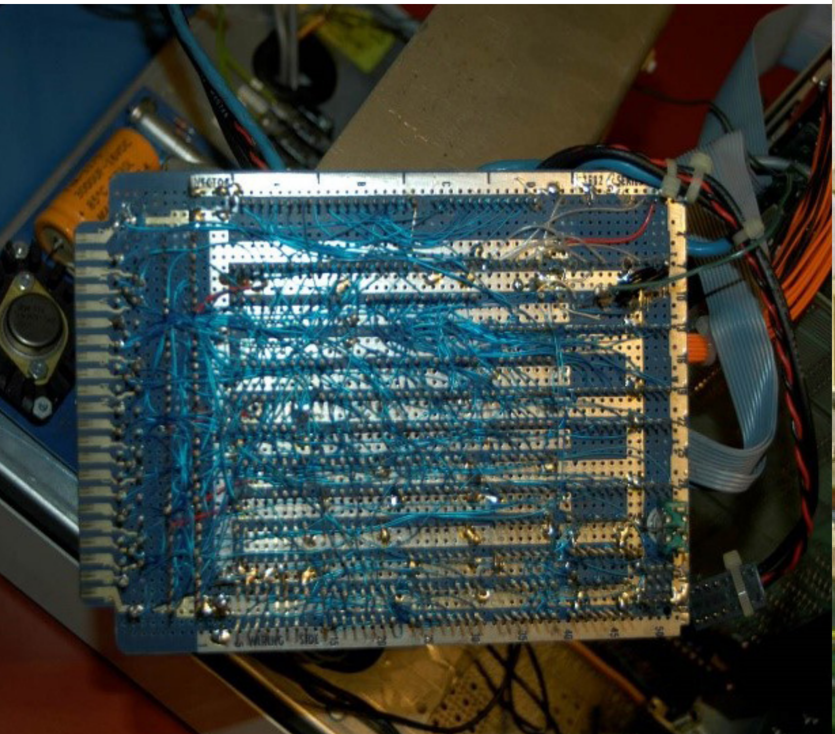


Our "Blue Box", the first model microcomputer in the world

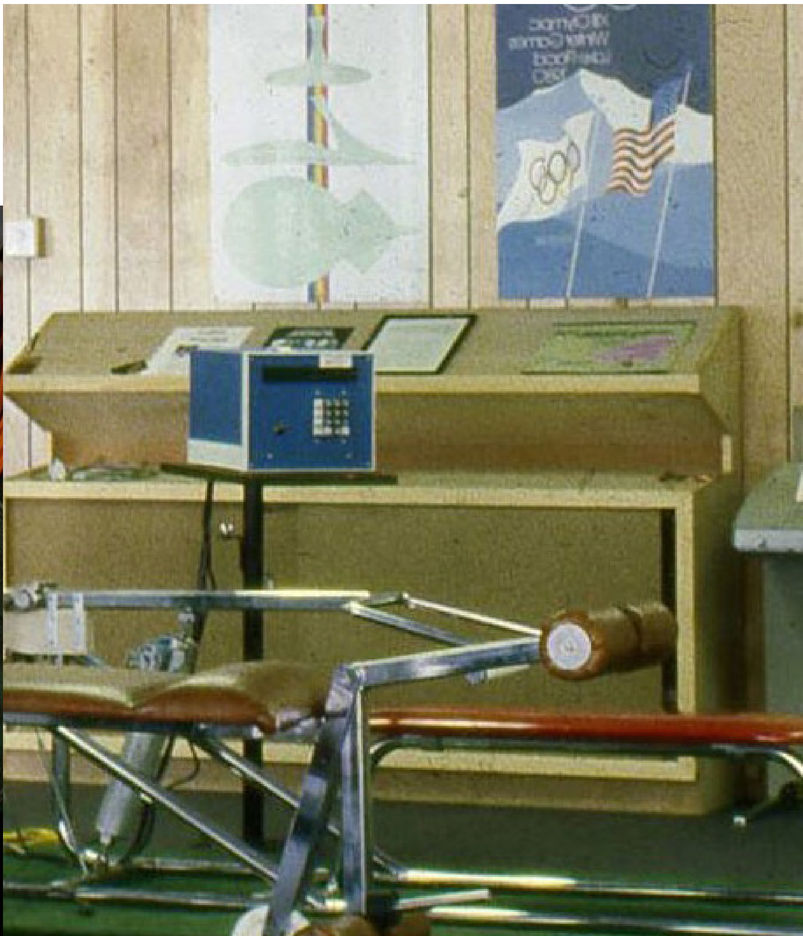
strength provided by the muscles must be evaluated and regulated so that there is enough force to lift the cup, but not so much that the cup is smashed into the mouth. There are continuous interactions between the arm/hand position and the lifting force in order for a person to drink water from a cup. The human brain must measure and regulate these actions continuously. This feedback loop system of direction, measurement, and control of the human body was what we were trying to duplicate in the CES. Fortunately, Peter and Justin were brilliant hardware and software engineers, so they were able to understand my ideas and explanations and then create the product I envisioned.

Peter and Justin concluded that they would have to build their own computer to control the spooler value, as well as the pressure and force transducers. They worked on the

We had to build our circuitry by hand. There were no electronics available to achieve the functions necessary



Our "Blue Box" integrated with the exercise machine



Our second model microcomputer to control the exercise machine

Exercise Machine with Data General micro-NOVA
http://arielnet.com/ref/go/1188

project for a year with many problems along the way. Every transducer, microchip, resistor, amplifier, filter, rectifier, voltage regulator, diode, semi-conductor, and other electronic parts had to be individually integrated and hand-soldered onto boards. The components, boards, motors, and switches fit snugly into a blue metal-framed box with a small screen and buttons on the front face. Our newly created micro-computer was christened the “Blue Box” for obvious reasons. The “Blue Box” was our own micro-computer and predated Apple. At that time, we were focused on building a computer brain to control our exercise machine rather than considering other uses for the micro-computer. Perhaps, if we had pursued it as a computer for the home or small office, who knows what would have happened to our company and us.

The “Blue Box” was an exciting development on our path to producing the computerized exercise machine of my dreams. The exercise machine’s brain would continuously need to know the magnitude of the hydraulic pressure inside the cylinder. With this information, the computer would have to rapidly adjust the pressure by regulating the valve. In addition, rapid and precise bar position would have to be received and processed.

Data from the various transducers provided all of the information needed to operate the exercise machine’s program. There were several additional limitations that we would have to overcome to make the equipment practical and producible. One necessary item was a device which could convert analog to digital data. This device would have be small and fast. The devices currently available for use on huge mainframe computers could perform this task, however, they were entirely too large and much too expensive for our needs.

The “Blue Box” could do everything necessary to operate the equipment. The user could exercise and read a small screen which provided instructions and feedback while the person followed a workout program. But the “Blue Box” was filled with components which required extensive time to wire and was, therefore, impractical to take into production.

Concept for the Wilson-Ariel Machine
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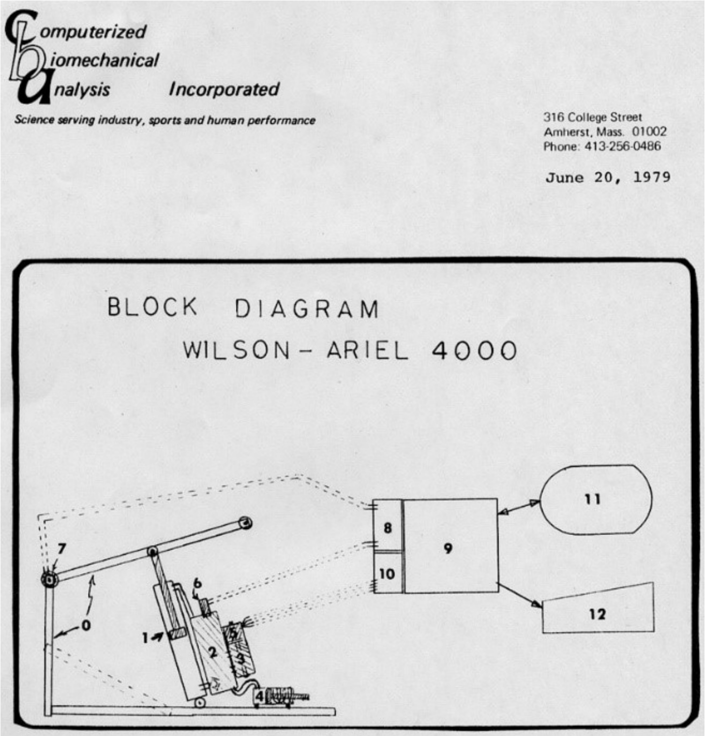


Computerized
Biomechanical
Analysis Incorporated
Science serving industry, sports and human performance

316 College Street
Amherst, Mass. 01002
Phone: 413-256-0486

June 20, 1979

BLOCK DIAGRAM
WILSON - ARIEL 4000

In addition, we all recognized that although our creation was functional, it was inelegant in appearance.

We had several candidates to consider for computers to replace the "Blue Box". At the time, CBA had in-house computer capabilities which had eliminated our dependence on the university's mainframes. We had purchased a Data General NOVA computer after they had been introduced in 1969.

The NOVA was packaged into a single rack mount case and had enough power to do most simple computing tasks. Our business was one of the many science laboratories worldwide which had purchased one of the more than 50,000 units sold. We were able to perform all of our CBA biomechanical work on the NOVA and it appeared to be an excellent interim step to use for the exercise machine's "brain". Ideally, we would need something smaller in the future, but the NOVA was more versatile and attractive than the "Blue Box", for the time being. However, we would continue to search for the perfect small computer.

We also needed a replacement for the original exercise unit. We had used the old Universal, one-of-a-kind frame, but the future design would have to be more functional as well as elegant in appearance. Ann and I had located a small firm in Framingham, MA which was about an hour's drive from our Amherst office. The company was owned and operated by two brothers, Joe and Frank Capelli, and they made hydraulic valves for a variety of customers. The majority of their customers wanted "active" hydraulic valves and packs for use on equipment such as cranes. We contracted Joe and Frank to make the frame for the exercise machine in addition to the hydraulic pack. In this way, the two things would fit together nicely since they had been designed that way.

Our hydraulic pack, however, needed a spool valve. Joe and Frank purchased the spool valve from a company in Connecticut. Their suggestion was for us to see if the Connecticut company could make the frame as well as the hydraulic pack with the spool valve. They explained that this would be a more efficient way to manufacture everything in one place. Perhaps this company could make everything for us at their site. Ann and I thanked them for this gracious suggestion since they were relinquishing their opportunity to make money manufacturing our system. However, Joe and Frank felt that this alternative option was better for us.

The Wilson-Ariel Exercise Machines
http://arielnet.com/ref/go/1190

• Each user's workout and diagnostic history can be maintained through the massive data storage.

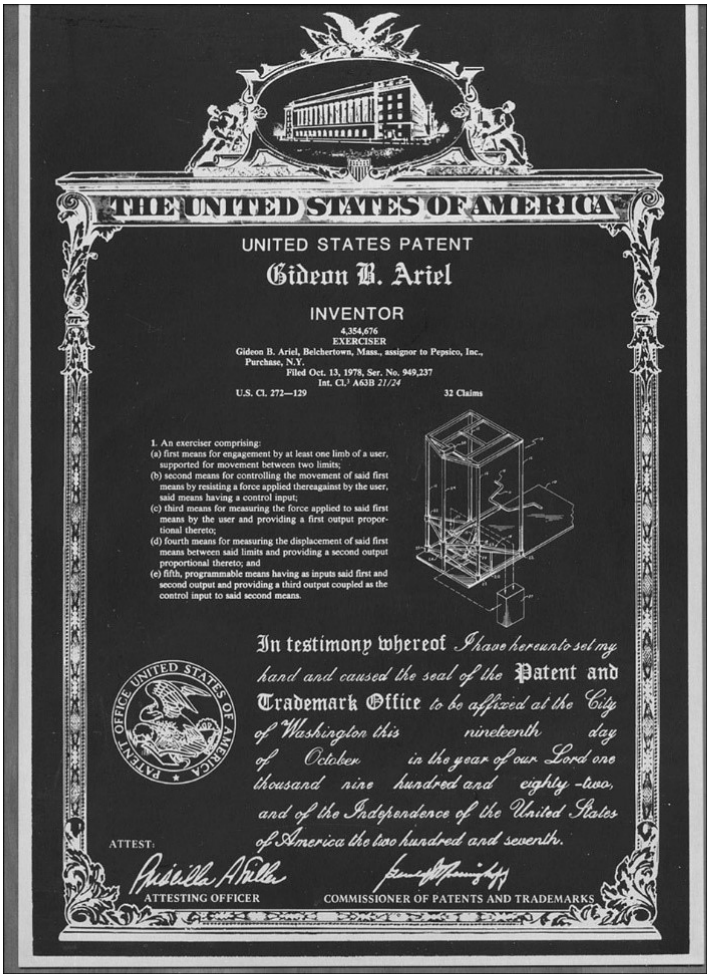
• Immediate feedback exercise monitors progress through a 19" color graphics screen in an interesting, informative and exciting manner.

• Graphics terminal provides printed copies of user data.

• User s
elimi

• Extremely easy to operate with self-pro
that allow interaction between the us

• Total flexibility in developing specific training or rehabilitation



THE UNITED STATES OF AMERICA

UNITED STATES PATENT

Gideon B. Ariel

INVENTOR

4,354,676
EXERCISER
Gideon B. Ariel, Belchertown, Mass., assignor to Pepsico, Inc., Purchase, N.Y.
Filed Oct. 13, 1978, Ser. No. 949,237
Int. Cl.³ A63B 21/24
U.S. Cl. 272—129 32 Claims

1. An exerciser comprising:
(a) first means for engagement by at least one limb of a user, supported for movement between two limits;
(b) second means for controlling the movement of said first means by resisting a force applied thereagainst by the user, said means having a control input;
(c) third means for measuring the force applied to said first means by the user and providing a first output proportional thereto;
(d) fourth means for measuring the displacement of said first means between said limits and providing a second output proportional thereto; and
(e) fifth, programmable means having as inputs said first and second output and providing a third output coupled as the control input to said second means.

In testimony whereof *I have hereunto set my hand and caused the seal of the* Patent and Trademark Office *to be affixed at the City of Washington this nineteenth day of October in the year of our Lord one thousand nine hundred and eighty-two, and of the Independence of the United States of America the two hundred and seventh.*

ATTEST:

Priscilla A Miller

ATTESTING OFFICER

COMMISSIONER OF PATENTS AND TRADEMARKS

One of the 19 patents issued for the Ariel Computerized Exercise Machine
http://arielnet.com/ref/go/1193

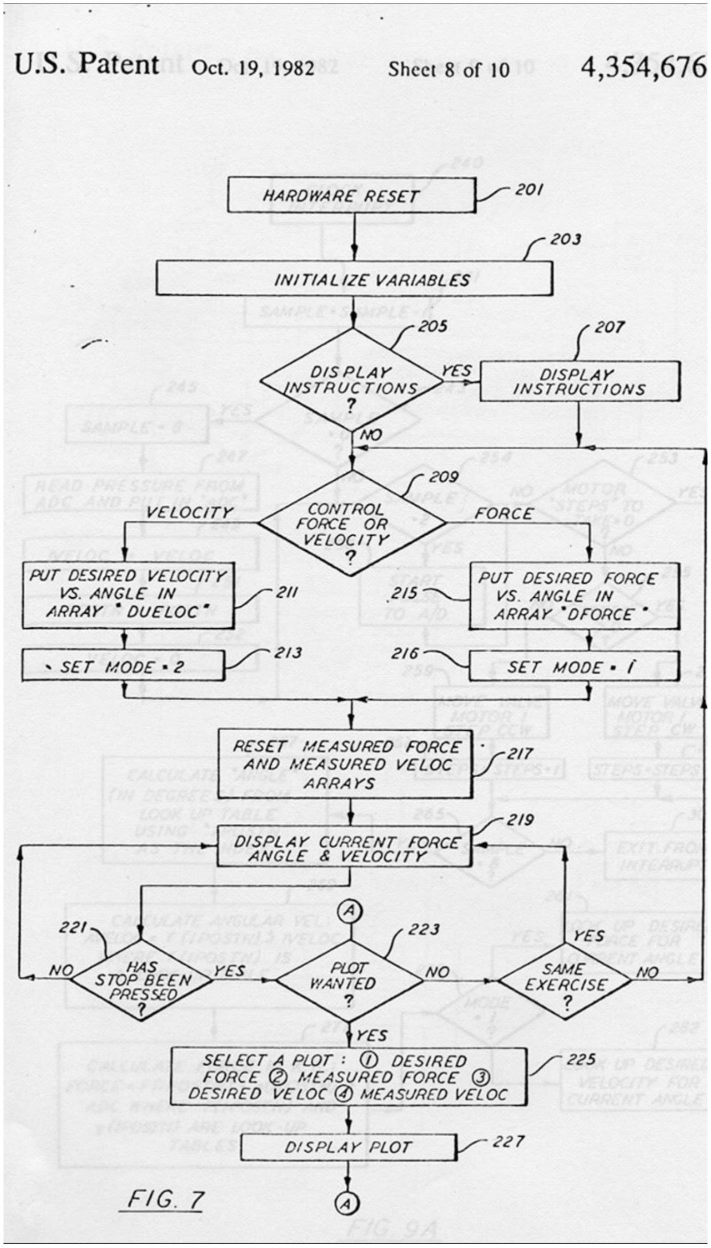


FIG. 7

We visited the Connecticut company that the Capelli brothers had recommended. As Joe and Frank had speculated, the company could manufacture the frame and the entire hydraulic assembly and for a reasonable price. We were pleased with the arrangement and immediately worked on integrating our computerized electronics with the frame and hydraulic pack. As soon as had our first system tested and ready, we were able to demonstrate it.

The first significant client expressing interest in our computerized exercise device was Wilson Sporting Goods. The initial contact had been a phone call from a Mr. Cooksey who explained that his job was to find new items for Wilson to consider. We arranged a late morning meeting and happened to be looking out the office window when a car parked in front of the office. A trim, well-dressed man got out of his car and put on the jacket of his three-piece suit. The gentleman came into the office and introduced himself as Mr. Cooksey from Wilson Sporting Goods. We demonstrated the prototype computerized exercise machine unit and described the continuing developmental processes that were underway. At the conclusion of our day-long meeting, Mr. Cooksey said that this seemed like an excellent new product for Wilson and that he would get back to us soon. Needless to say, there were smiles on everyone's faces as we were thrilled to hear positive feedback from an outsider for our project.

Nearly two weeks passed before Mr. Cooksey's next visit. Again, we were working in the front office when he parked in front of the building. This time, Mr. Cooksey took his coat off, put it in the back seat of his car, and then came into the office. This visit we presented the unit's progress in greater detail. We determined what remained to be done, and considered some of the ideas that Wilson had about the future product. After four intense hours of work, Mr. Cooksey left with a promise to call within a few days.

JULY 1982

SKY

DELTA AIR LINES INFLIGHT MAGAZINE

- SPECIAL SECTION: MANKIND AND MACHINE
- A NEW ENGLAND SAMPLER
- OUR PRICELESS, PROFITABLE PETS
- THE CHILI CHALLENGE
- PREFERRED STOCK: NASCAR PORTFOLIO
- NASTY HABITS

MODE: Sports

t Coto Research Center, $3 million worth of computer technology helps athletes improve abilities.

Power hitters slugging 80 homers a eason ... running backs rushing for ,000 yards a year ... milers streaking cross the finish line in 3:30 ... pole aulters clearing the bar at 20 feet.

These unparalleled sports achieve- nents are within the grasp of athletes who eek greatness and goals through the ew science of biomechanics: the com- uter analysis of athletic motion.

In its infancy, biomechanics is already oing more to raise the limits of human erformance than all the steroids ever njected. And by the year 2000, computer- zed exercise equipment and ultra-sophis- icated measuring devices will be as much part of the training room, clubhouse and health spa as Nautilus equipment is now.

"Anything you can do, you can do better through biomechanics – even if you're a superstar," declares Gideon Ariel, the Vince Lombardi of biomechanics. "Some superstars could do 50 percent better."

That's because the John McEnroes, Walter Paytons and Sugar Ray Leonards of today simply haven't reached their physical limits yet. But tomorrow's stars will approach the threshold of their own athletic perfection through biomechanics, says Ariel.

He heads the Coto Research Center in Coto de Caza, California, a sports clinic which relies on $3 million worth of computer technology to enhance athletes' physical rehabilitation and improve performance.

Experts like Ariel film an athlete i tion using highspeed movies whic converted to frames of stick figure computer analysis. Detailed calcul then are made of body movement, t and forces that create or result movement.

The information gained can do m improve performance than weeks of tice. For example, Ariel's com showed that U.S. Olympic discus th Mac Wilkins was not striding right, ca his front leg to absorb energy that otherwise be utilized in his throw. W changed his stride and shattered the record at the time by nearly six feet.

When Jimmy Connors' serve was puter analyzed, Ariel discovered tha tennis star's feet were leaving the g at a crucial moment, reducing the ve of his serve by 20 miles per hour. Co made the necessary adjustments sped up his serve.

The feats of today's stars could commonplace by the year 2000, say Ward, conditioning coach for the D Cowboys. "If we do a biomechanic ysis on (running back) Tony Dorset find he's playing at only 60 percent physical capabilities, we'd help him m few adjustments. Then there'd be no son why he couldn't rush for 3,000 ya season.

"Computers will help improve the q of players and, as a result, there is single record that couldn't be broken.

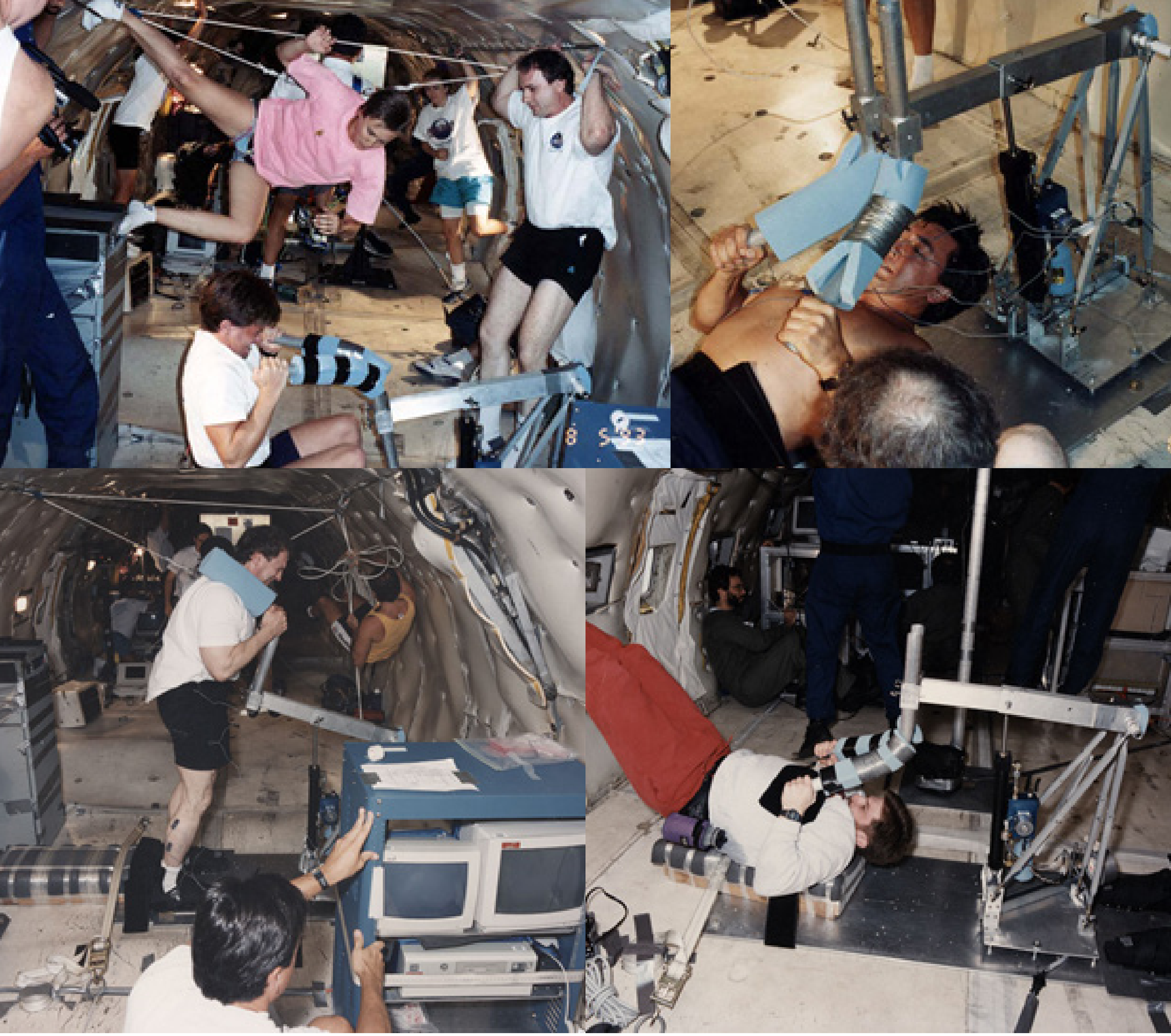
Although biomechanics will id weaknesses and assign proper tr instructions and adjustments, it c measure one very important factor athlete's state of mind. "Biomech can't consider his psychological ma desire to achieve or other outside fa which could affect performance," a Ariel.

Nevertheless, Ariel, who is chairm the Biomechanical Committee of the Olympic Committee, believes the science will help the athlete "to the where the body is performing at its when the anatomical structure can't form any better."

Biomechanics will assist the athle another way – improved sports e ment. "Bugging" golf clubs, tennis rac and ski poles with electronic sens already spurring new designs and m

Article published in "Sky"
http://arielnet.com/ref/go/1195

The Wilson-Ariel Computerized Machines running on a Micronova Mini Computer



Testing modified Computerized Exercise Machine for NASA on a KC-135 plane
http://arielnet.com/ref/go/1196

Mr. Cooksey's third visit was scheduled with an additional Wilson representative. He was to be accompanied by the corporate attorney. Ann and I were happy about the progress with Wilson and our CES "baby", but we were apprehensive about a lawyer. The day of the meeting we were waiting for the Wilson contingent to arrive. This time, Mr. Cooksey exited his car, put his coat and tie in the back seat of the car, and loosened his top shirt button as he walked into our office. I suppose that our normal dress-code of blue jeans, T-shirts, and tennis shoes were influencing his choice of attire. We breathed a sigh of relief as he seemed to us to be relaxed, rather than up-tight as in an end-of-a-dream demeanor.

Mr. Cooksey introduced us to the corporate lawyer and asked us to demonstrate the machine for her. Of course, this was the day that everything that could go wrong, did go wrong. The computer was obstinate and would not boot. After several attempts, the computer connections were made and the demonstration began. The demonstration was proceeding nicely until the hydraulic pack assembly began to squeak. This was not some ordinary squeak but rather loud, persistent, and obnoxious noises. When the bar was pushed up, there was a loud squeak and when the bar was pushed down, a different but equally unpleasant noise accompanied the movement. I wish I could have turned red with embarrassment, but instead I was focused on discovering the cause of this unexpected, unusual, and unpleasant problem.

As we attempted to correct the problem as quickly and unobtrusively as possible, the lawyer turned to Mr. Cooksey and with a slight smile she asked him "Are you sure that you want to spend this much money on a squeak?" Her comment broke the evil spell since the CES performed perfectly for the remainder of the demonstration. We were eventually able to discern what had caused the noise and eliminate the problem.

Before they left, Mr. Cooksey and the lawyer informed us that Wilson would be proceeding to form a contract between our two companies for the CES product. We could expect to hear from them soon. Ann and I were very excited, as were the other staff members. We invited our entire office staff to join us for dinner at the nicest restaurant in Amherst where all of us could celebrate this momentous event.

We were fortunate to have begun our relationship with Wilson at that time. In 1970, the company was acquired by PepsiCo, Inc. which wanted to take advantage of Wilson's high profile and leadership role in the industry in order to enhance its own image. In return, PepsiCo provided Wilson with the financial base that was needed for the company to expand into the international market. By 1976, Wilson had opened a manufacturing plant in Galway, Ireland, to enter the rapidly growing market for tennis products.

Ann and I working with NASA to integrate the CES with the Astronauts training

Nevertheless, the company's most important growth opportunities were still in the United States. During the 1970s, Wilson was chosen to supply the official basketball of the National Basketball Association and the official football of the NFL. Wilson provided almost all of the uniforms for teams in Major League Baseball, and the company also supplied the U.S. Summer Olympic team with all of its official uniforms and clothing. The publicity garnered from these agreements was unprecedented—the Wilson brand name was not only known throughout the United States but around the world.

One of the strategies that Wilson employed over the years to increase sales and enhance its product image was to pursue the endorsement of professional athletes. During the 1980s, Wilson products were endorsed by more than 100 of America's most famous and well-respected athletes, including Sam Snead in golf, Walter Payton in football, Michael Jordan in basketball, and Roger Clemens in baseball. This strategy paid off handsomely in sales, as golf club professionals and tennis club professionals used and promoted Wilson products. At the same time, Wilson entered into contractual agreements with national and regional retailers across the United States to sell their products.

Although the CES was not a main-stream sports product compared to traditional American ball-related sports, it was a "tool" that could easily be utilized by those sports as well as in additional areas. With a product appealing to sports, fitness, recreation, and many other venues, it was a potential money maker for Wilson Sporting Goods. Clearly, Mr. Cooksey had convinced his superiors of this potential and, thus, their positive response.

We were extremely lucky that during our time of innovation and invention on the CES, the computer industry was experiencing a revolution as well. Although we were satisfied

Michael C. Greenisen

with the performance and reliability of the Data General micro-NOVA, the size and price tag were significant problems for use with our CES. We continued to search for a suitable alternative.

Simultaneously with our search for a smaller, less expensive computer, we continued to work on programming the micro-NOVA because that was the system which Wilson Sporting Goods preferred. We had discussed the computer situation with Mr. Cooksey during one of his visit. Wilson Sporting Goods was more comfortable using a more well-known and established company rather than trying to adapt a hobby-type computer. Therefore, we continued to develop the software for the CES on the micro-NOVA.

In 1979, we signed the contract with Wilson Sporting Goods. The basic plan was that they would manufacture and sell the CES, and CBA would receive royalties on the sales. Additionally, CBA would receive monthly consulting fees for continued development and advancement of the CES components, designs, and programs. Wilson committed to preparing the documentation and obtaining patents on the CES and its various components. Although this process was costly, it would protect Wilson and us for our investments of time, money, and intellectual concepts. Wilson planned to manufacture the CES at their Chicago facility. They purchased the current inventory from the Connecticut Company with whom we had worked, and then Wilson terminated that relationship.

The arrangement with Wilson Sporting Goods seemed to be a dream come true, and we occasionally pinched ourselves to be sure that it was a reality. We were excited by their commitment to CBA and to the development of the CES. The Wilson personnel was as enthusiastic as we were and had chosen to name the CES the "Wilson Ariel 4000".

They intended to subcontract some of the components such as the hydraulic pack assembly and the frame portions. They would purchase those components, as well as the micro-NOVA, in sufficient quantities to obtain large discounts from the different subcontractors. These cost-saving measures would translate into lower overhead costs so that the final CES product could be sold at a reasonable and competitive price.

The Wilson plan was multi-level, with the initial target being the higher priced medical market, including physical therapy. The next tier would be corporate fitness programs and larger university athletic programs. Eventually, they expected to enter the larger, less expensive retail market for sports enthusiasts.

We had an additional vision for the CES which was the American armed forces. Each military branch performed different tasks, but every individual, regardless of rank, needed to maintain a level of fitness. The CES could provide a tool to help achieve the fitness levels set by each unit and could, uniquely, provide stored information on individual performance, comparisons between or among groups, as well as historical fitness levels, to name a few options. Each branch or unit could design the exercises which prepared them for their unique, specific fitness demands. Because of the size and notoriety of Wilson, we anticipated that they could successfully access this potential market.

Mr. Cooksey had been our initial contact with Wilson Sporting Goods, so we were disappointed when he told us that he was being reassigned. His primary job was to find new and exciting products and we had been one of these stimulating projects. Now, he would have to go back to the search for new things for the company.

Our new contact was Mr. Bill Morrisroe, one of the Senior Vice Presidents, and Mr. Richard Smith, the new corporate council from PepsiCo to Wilson. They were instrumental in concluding the relationship with the manufacturer in Connecticut, cementing the arrangement with Data General, and providing the law firm for the CES patents.

Mr. Morrisroe assigned Mr. Lou Tabickman to be the general manager for an entirely new division within Wilson named Fitness Systems. They hired 20 people to continue the CES development in conjunction with CBA's continuing co-operation and contributions. The development stages included immediate improvements in (1) software, (2) work with their designated electronics manufacturer to develop plug-in hardware boards, (3) improved stepper motor drive boards, and (4) more attractive external framing for the CES. These specific goals would enhance the external appearance of the machine and would significantly improve the internal hardware and computer software.

Wilson had made it clear that they were planning to develop, manufacture, and market the most sophisticated exercise machine that had ever been created. Their plan was to create a first-class system and avoid any suggestion that this was merely a gadget. In addition to the generous licensing agreement, Wilson had also included a consulting agreement to maintain the development ideas and to smooth any production difficulties. We were more financially secure than we had been as a single company working on individual service contracts. This was clearly a fantastic path for our immediate future. Although the financial benefits were greater than we had expected, we were all devoted to the CES project. The CES was our "child" and we were totally enmeshed in the care and rearing of our "offspring".

The early days of our relationship with Wilson Sporting Goods to develop and refine the design—and to patent as many components as possible—was quite stimulating and enjoyable. Everyone at CBA was enthusiastic about the project, and eagerly participated in each task that Wilson assigned. The patent work was quite specific and demanding, but we were able to provide dated documentation and purchase invoices to substantiate all of our claims. It was tedious but fulfilling work. The technical details involved with the hydraulic pack required many hours and great effort in order to perfect the final version.

From 1978 to 1981, we were also involved with opening a laboratory in Coto de Caza, California. This required quite a number of transcontinental trips with many of them routed through Chicago. Once the facility in California was available, it would provide an additional location for demonstrating the CES.

The fellow that Wilson had assigned to be the manager of the Fitness Systems division, Mr. Lou Tabickman, seemed to be exerting great effort to impress both his superiors and me. He was responsible for hiring the twenty people in Chicago which included engineers, office staff, and even sales personnel. Since I had never worked in a large corporate entity, it seemed a strange organization to me. I assumed that the development steps would be in logical order. First, the product would be perfected, then manufacturing procedures would be implemented, and, lastly, marketing and sales activities would commence. However, under Lou Tabickman's guidance, all these steps were implemented simultaneously.

Research Center in Coto de Caza, CA
http://arielnet.com/ref/go/1198

About once a month, Lou and I met. He had some habits that really irritated me, but I tried not to encourage his annoying behavior and I ignored many of the things he did. I never knew if he did things to annoy me on purpose or whether this was just his character. Unfortunately, it made no difference and we clashed on several occasions.

Despite my discomfort with Lou, the CES project continued to develop with excellent results. The law firm that Wilson had hired solved all of the necessary contractual obligations for hardware, such as computers, stepper motor boards, and other electronic components, and obtained several patents on the CES. The frame and hydraulic pack assembly were improved in external appearance, and some beautiful logos were designed.

We demonstrated the equipment at several national shows. Wilson's marketing genius produced fantastic results. The technique which they utilized was to present the CES as news. This enabled them to have the CES in the print media and presented on television in prime-time as the new, exciting, and scientific method of exercising. The uniqueness of an exercise machine with a brain was exciting and truly newsworthy for local stations. I was so proud of this accomplishment and more than happy to describe it to anyone who would listen. I did not intend to brag or be egotistical in my outlook; I truly believed, then and now, that the CES was unique and effective for fitness and training.

Unfortunately, the most disruptive encounter with Mr. Tabickman occurred during a fitness trade show in Las Vegas, Nevada. I enthusiastically demonstrated the machine in the Wilson booth every day—from the beginning to the close of the exhibits. Suddenly, one of my first, pre-Wilson, customers approached me with an angry expression on his face.

"Why didn't you tell us that you have a small home unit?" he demanded.

"What are you talking about?" was my flabbergasted response.

"Upstairs on the 14th floor, Mr. Tabickman and the other Wilson representative are having a cocktail party and are demonstrating a new, small home CES unit," he answered.

I was speechless and the look on my face must have convinced him that I was unaware of the CES unit or the party that he had just described. "Show me," I told him.

We rode in the elevator to the 14th floor and I followed him to the room. After he knocked and the door was opened, I marched in as though I have been invited. It was exactly the way it had been described. There were tables covered with food and drinks. More shocking to me was a small Wilson-labeled home CES unit in the center of the floor.

I walked quickly over to Lou, who was standing next to the unit, and demanded to know what was going on and why I had not been informed. Lou's response was that I did not have to know everything, since he was in charge.

My response was, "Yes, I do have to know everything since this CES is my invention." I pivoted and walked out of the room.

Available microcomputers in the early '80s

I returned to the Wilson booth in the main exhibit hall and began to pack my briefcase. Just then, Ann arrived from the airport having flown in from Massachusetts. I told her that we were leaving and, despite the surprised look on her face, she turned and we left.

We took the next flight to Amherst. The first thing the following morning, I gathered the Amherst office staff in our conference room. After describing the preceding few days and the encounter with Mr. Tabickman, I announced that we were on our own now. We were going to develop the "Ariel Computerized Exercise Machine" and it was going to be completely controlled by a microcomputer, such as a Radio Shack computer, and that we were no longer going to utilize the Data General computer. Furthermore, I set a deadline for one month from that moment when we would demonstrate this finished product to the president of Wilson Sporting Goods in our office. The staff looked stunned but were almost immediately animated with ideas for accomplishing this task.

My insistence that we employ a microcomputer stemmed from the belief that smaller, faster, and more flexible computers would constitute the future. Large mainframes and even the mini computers currently available would be utilized by large corporations who needed to process huge quantities of data. Our need was for smaller, faster, and nimbler computer capabilities. We had previously developed the "Blue Box", but it was too labor-intensive for us to mass-produce. I insisted that the CES would have to operate on the best available microcomputer.

A microcomputer is a computer with a microprocessor as its central processing unit (CPU). It includes a microprocessor, memory, and input/output (I/O) facilities. Such computers are physically small compared to mainframes and minicomputers, such as the micro-NOVA. Many microcomputers (when equipped with a keyboard and screen for input and output) are also personal computers (in the generic sense). The Commodore 64 was one of the most popular microcomputers of its era and was the best-selling model of home computer of that time.

The abbreviation "micro" was common during the 1970s and 1980s, but has now fallen out of common usage. It is most commonly associated with the first wave of all-in-one 8-bit home computers and small business microcomputers such as the Apple II, Commodore 64, BBC Micro, and TRS 80. The period from about 1971 to 1976 was sometimes called the "first generation of microcomputers". These machines were primarily for engineering development and the personal use of many hobbyists. The MITS Altair played an instrumental role in sparking significant hobbyist interest. It eventually led to the founding and success of many well-known personal computer hardware and software companies such as Microsoft and Apple Computer. Although the Altair itself was only a mild commercial success, it helped spark a huge industry.

By 1977, the introduction of the second generation of micro-computers, known as "home computers", made them considerably easier to use than their predecessors. Previously, the earlier versions often demanded thorough familiarity with practical electronics in order to make them operational. The ability to connect to a monitor (screen) or TV set allowed visual manipulation of text and numbers. The BASIC language, which was easier to learn and use than raw machine language, became a standard feature. These features were already common in minicomputers with which many hobbyists were familiar. In 1979, the launch of the "VisiCalc spreadsheet" (initially for the Apple II) first turned the microcomputer from a hobby for computer enthusiasts into a business tool.

The TRS-80 was Tandy Corporation's desktop microcomputer model line and was sold through Tandy's Radio Shack stores in the late 1970s and early 1980s. The TRS-80 was one of the earliest mass-produced personal computers. The first units, ordered unseen, were delivered in November 1977. Among the notable features of the original TRS-80 included its:

1. Full-stroke QWERTY keyboard
2. Small size
3. Its floating point BASIC programming language
4. An included monitor
5. Starting price of $600

By 1979, the TRS-80 had the largest available selection of software in the microcomputer market. This included FORTH which was the language we had selected to control the stepper motor for our CES equipment.

Radio Shack marketed the TRS-80 color computer, affectionately nicknamed "CoCo", as a home computer in 1980. It was one of the earliest of the first generation of computers marketed for home use in English-speaking markets. The original version of the Color Computer shipped in a large silver-gray case with a calculator-like chiclet keyboard and was available with several memory sizes. Versions with at least 16K of memory installed shipped with standard Microsoft Color Basic or (optionally) Extended Color Basic. The TRS-80 used a regular TV for display and the TV-out was the only available connection to a display device.

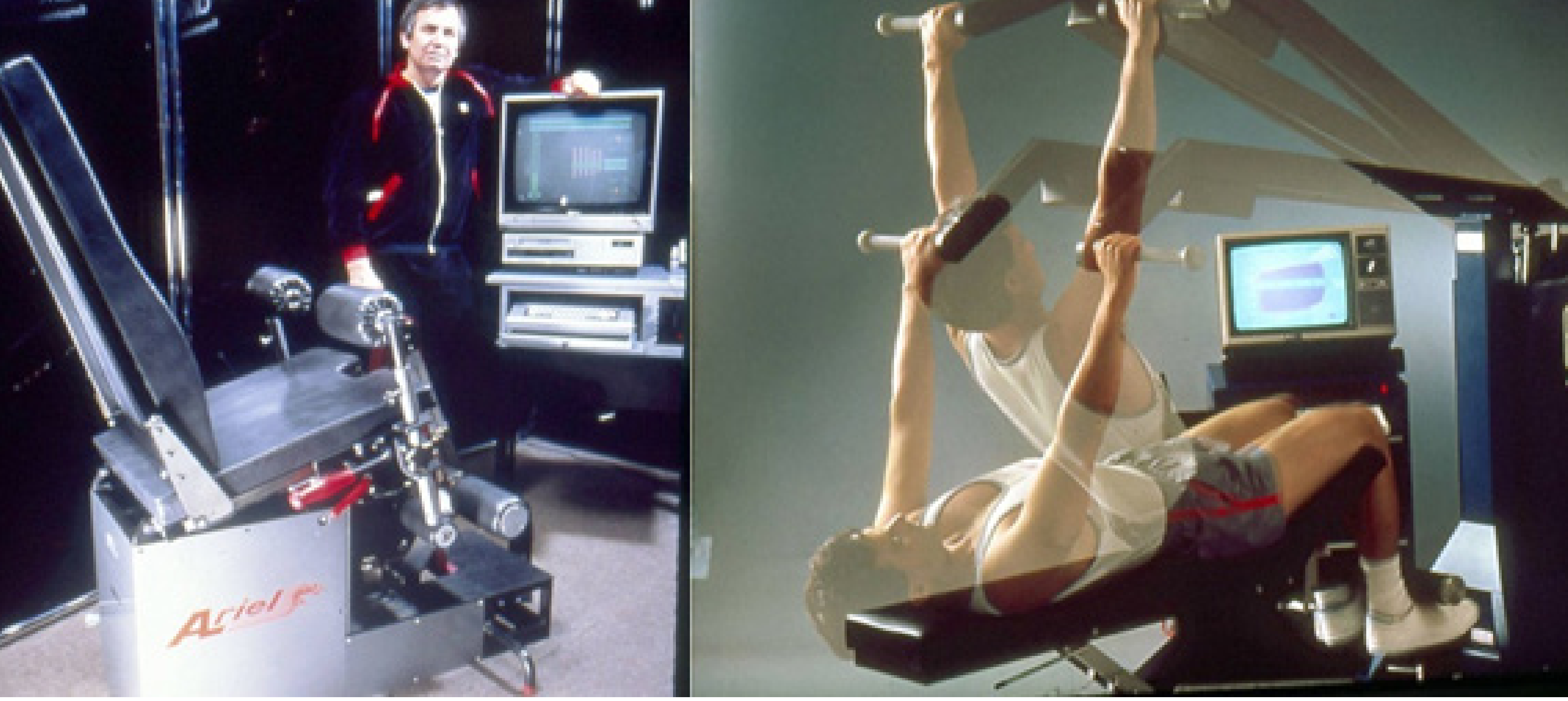
For years, we had been working on both software and hardware developments for the CES as parallel efforts. For example, with each change in the valve configuration, we usually needed to adapt the software to control it. We were searching for a microcomputer with enough processing speed, controllability features, and for the right price. We tried computers from a number of different companies and, eventually, focused our efforts on the Radio Shack TRS-80 which used the Motorola 6809 chip.

Original TRS-80 microcomputer

The Motorola 6809 chip was introduced in 1978 and was a major advancement over its predecessors. Among the significant enhancements were the use of two 8-bit accumulators into a single 16-bit register, two 16-bit index registers, and two 16-bit stack pointers. In addition to these technical enhancements, for our specific purposes, the 6809 was a faster and more easily controlled chip to handle our increasingly sophisticated programs.

After Radio Shack introduced a floppy drive in 1978, we developed our own console. Our CES console had the Radio Shack TRS-80 nested within the frame, exposing only the keyboard and next to it were two double-density floppy disk drives.

First used to store data in 1962, magnetic disks initially provided supplemental memory in high-speed computer systems. They were considered ideal for this type of retrieval because a user could access information non-sequentially. The principle of magnetic recording is fairly simple. The magnetic recording (writing) and playback (reading) are carried out by a computer's disk drive whose function corresponds broadly to that of an audio record player. Data transferred from the computer to the floppy disk is relayed in the form of a binary code and received in the form of magnetic pulses, while the disk conveys magnetic patterns that the computer receives as a binary code. This code uses only l's and 0's which the disk represents as single magnetic pulses and the absences of pulses, respectively. Binary code is used



The first Computerized Exercise Machine running on the Radio Shack

because it most effectively utilizes the natural two-state characteristics of electricity and magnetism.

To record information on a disk, a magnetic head contacts the disk's recording surface and magnetically imprints data onto it translating the computer's binary codes into the disk's magnetic pulses. Once a magnetic pattern consisting of many pulses and absences has been recorded, the disk retains the encoded information just like a permanent magnet. Retrieving information from the disk involves the opposite process. The magnetic head senses the magnetic pattern on the disk's recorded surface and converts it back into an electronic binary code. The computer then "reads" this information and uses it to perform calculations or translates it into letters and figures for display on the monitor.

Floppy disks, which were smaller and more flexible portable versions of the earlier magnetic disks, were introduced during the 1970s. Although they were unable to store as much data as larger more conventional disk drives and the data could not be retrieved as easily, floppy disks became extremely popular in situations where flexibility, low cost, and ease of use were important. The term "floppy disk" appeared in print as early as 1970. The first floppy drives used 8-inch floppy disks but were replaced by the 5-¼ inch model.

The floppy disk seems so simple and primitive today, but it changed everything since it was an enormous improvement on the unfriendliness and complications—in addition to cost—of the larger systems of the day. Until the late 1970s, personal computer owners had to write most software applications for tasks such as word processing and accounting. With the floppy disk and transportable diskettes, companies could create programs, write them on the disks, and sell them through the mail or in stores. At that point, it became possible to have a software industry. Anyone who owned a computer that used floppies could share programs and data with each other. Basically, the floppy disk converted microcomputers into personal computers. As time passed, smaller 3.5-inch diskettes were introduced with a sturdier construction and longer duration of use.

Regardless of size, a floppy disk was a storage medium and was composed of a disk of thin and flexible magnetic storage medium. Each one was sealed in a rectangular plastic carrier lined with fabric that removed dust particles. They were read and written on by a floppy disk drive (FDD).

In addition to utilizing floppy disks to operate the CES, we created a unique invention which was born out of necessity. At the time, diskettes were read only by the disk drive head located above the diskette. The problem with this system was that the diskettes, which were made of a thin plastic material, were easily worn through and had surprisingly short lifespans. We even had some program diskettes that became so porous that—when they were held up—light shown through them.

Dr. Wise invented a unique program which allowed the computer to read and write on both the top and the bottom of the diskette. This provided a mirror backup for the program. His program instructed the computer to find the correct track on the opposite side, if a track on one side was damaged or unreadable.

This read-write option for the top and bottom of the diskette was so unique that it was patented by IBM long after we

Computer Revolution - Back to the Basics
http://arielnet.com/ref/go/2710

had developed our program. Some of the patents describe this process as the recursive method for protecting data. At that time, many things in the developing computer world were needed but unavailable. This innovation associated with our CES system to read the diskette from the top and from the bottom was essential for lengthening the lifetime of each diskette. We created our own solution without realizing the patentable uniqueness of it and IBM patented it years later.

Our plan for the CES was to use the drives to operate the entire CES system with floppy drives. We intended to turn the computer on—or boot as it was known at the time—operate the CES program, and save the generated exercise data. The entire system could be housed in the console we designed. Only the computer's keyboard was exposed as were the openings for the floppy disk drives at the front of the console. The console design was similar to a simple desk. The remaining computer and floppy drive components were hidden within the console and, on the top of the console, was a color television which served as the display device. There was sufficient space on the top of this desk-like console to arrange backup diskettes, manuals, or other materials.

While Peter, Justin, Alan, and Jeremy continued to develop and refine the computer and programs, I searched for a solution for the analog to digital conversion. I decided to attend an electronic conference in Chicago where I strolled up and down the aisles of displays, and perused the numerous and varied devices presented. There seemed to be miles of rows packed with booths. At one of the booths, there was a display of computer games which were running on Atari computers. The original Atari company was founded in 1972 by Nolan Bushnell and Ted Dabney and was a pioneer in arcade games, home video game consoles, and home computers. The company's products, such as Pong, helped define the computer entertainment industry from the 1970s to the mid-1980s.

I watched with fascination as one of the fellows in the booth controlled a submarine on a screen and fired computerized torpedoes at some unseen enemy. The fellow was manipulating a joystick to control the movements of the submarine and to aim the firing mechanism at the target. I realized immediately that he was controlling the digital signal on the screen with the analog interface of the joystick. I introduced myself and the fellow told me that his name was Dennis Kitz.

Mr. Kitz was using the Atari computer to operate the games which he had stored on computer cassettes. I described to Mr. Kitz what I needed and inquired whether he thought that his analog-to-digital device could be adapted for use with our exercise machine. He was relatively confident that he could make the necessary modifications but that he would come to our Amherst office to see everything first hand. We arranged for him to come to Amherst as soon as possible following the convention.

The new CES
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Our Multi-Function and Arm/Leg/Back Machines running on modern PC
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One sunny day shortly thereafter, Mr. Dennis Kitz rode his big, black Harley Davidson motorcycle up to our office and parked in front to the amazement of a group of passing elementary school children. There were quite a number of "ooohs" and "ahhs," as the children walked by on their way to school. I could not determine whether the children were amazed by the motorcycle or by Mr. Kitz's large presence. Dennis was approximately six feet three inches with a hefty build, dressed in leather clothes and boots, and with a big black beard. Perhaps the school children thought that Black Beard, the notorious Pirate, had traded in his sailing ship for a Harley Davidson. He chuckled at the children's responses and said that it happens to him frequently. Actually, Dennis was large in statue but quiet in demeanor.

We showed Dennis what we had developed to this point. We demonstrated the Radio Shack TRS-80, the valves we were trying to control, and described the ultimate goal. He said he would try to design and build an analog to a digital device that we could use and then roared off on his motorcycle to his home in New Hampshire.

Dennis returned to our office a week later with a mechanism which Justin and Peter were able to interface with the Radio Shack computer. The device could read the signals from the hydraulic force and position transducers. Then, these analog signals were converted into digital form enabling the computer to process the data. From this point forward, the Radio Shack could drive the system using digital signaling.

The small analog-to-digital device that Dennis Kitz built for us was a significant advancement in the miniaturization process that we would have to aim for in the future if we were to develop a viable, marketable product. We wanted to take the designed board to a manufacturer who could mass-produce it and then we could install it into our system.

Alan and Jeremy were working long hours to finish the new computer programs to control the CES. I was putting pressure on them to have it completed before the president of Wilson's visit to Amherst. Ann was working long hours to maintain the other projects that CBA was working on for other companies. It was an extremely hectic time for all of us.

The meeting with Wilson was scheduled approximately three weeks after my confrontation with Mr. Tabickman in Las Vegas. They walked through our office door in order of importance: Mr. Beebe, the president, first, followed by one of his vice presidents, Mr. Malcolm Candlish, and lastly, Mr.

Tabickman. Ann and I met them in our front office as cordially as possible.

Mr. Beebe had replaced Mr. Calley as the president of Wilson. We had previously enjoyed a fantastic relationship with Mr. Calley. Mr. Beebe was younger than Mr. Calley and projected a calm, thoughtful demeanor. The few previous interactions with him had been quite pleasant. However, at this time, we were slightly apprehensive since we believed that the CES was a fantastic product with an extremely lucrative future but we had no idea what poison had been spread behind our backs.

Ann and I led them into the large development room which was adjacent to our motion analysis laboratory. We had set our new CES unit in the middle of the floor covered by a blue drape. After we were standing around the unit, Ann pulled off the drape to reveal the new, smaller CES unit with its own console. The console, with the computer, disk drives, and television was less than half the size of the current Data General micro-NOVA that the CES had been using in Chicago.

I proudly turned on the power and started the computer. The picture on the display screen read “Ariel Computerized Exercise Machine” and a voice announced:

“I am the Ariel Computerized Exercise Machine. Although I used to cost $45,000 dollars, now I only cost $5000. Let me show you how I work.”

I proceeded to demonstrate each function that the CES could perform. We had duplicated all of the actions that the large micro-NOVA-based CES could execute, but at a greatly reduced price. While I was showing the different options, I noticed that Lou Tabickman and Malcolm Candlish were walking around the unit searching for cables connecting the unit to another, larger computer. I guess they could not believe that in only three weeks, my staff and I had essentially performed a miracle. This unit was clearly far superior to the one that I had glimpsed in Las Vegas. After the demonstration, we requested a private meeting with Mr. Beebe.

We adjourned to our conference room and Mr. Beebe asked what should be the next step. Our suggestion was to completely replace the current staff of the Fitness Systems department from the top to the bottom. In our opinion, they were limited in their exercise systems background, were woefully inadequate in their technical knowledge, and were stubborn and inflexible when ideas were suggested.

The CES was new and exciting, and had tremendous financial potential which would go unrealized with the current Fitness System staff. Wilson Sporting Goods had a potential gold mine in its hands. The exercise, physical rehabilitation, sports team fitness and training markets were huge and growing exponentially. We also described the potential of the military market which could be as lucrative as the other ones. Wilson could easily be the market leader before the other companies even began to think about the financial po-

Conference on the CES in Korea

Ann collecting data on the CES Multi-Function Machine
http://arielnet.com/ref/go/1201

tentials. We stressed our commitment and devotion to the product and to Wilson and hoped that he would find a workable solution.

In addition, we described the excellent relationship we had enjoyed with all of the Wilson staff prior to the establishment of this new department. Everyone had been helpful and contributed to all of the projects in addition to the CES venture. We had several on-going research projects with Wilson and everyone we worked with was creative and inventive in the approach to the studies. It was only with the people in the Fitness Systems department that there were difficulties and resistance to any and all cooperative efforts. Our hope was that the entire staff of the Fitness Systems would be replaced with new, innovative people and the success of the CES would be realized by both of our companies.

Mr. Beebe thanked us for our candid appraisal of the situation and congratulated us on the newly developed CES. He even had some humorous comments about the announcement that the machine made when it was activated. Then he left the office with the two other Wilson personnel silently walking behind him.

Two weeks later, we were informed by Mr. Candlish that the Fitness Systems Department had been abolished. He knew of no plans to replace them or what the plans were at Wilson with regard to the CES.

Needless to say, we were elated that Mr. Tabickman and his underlings had been fired, but we were disappointed that we had learned of no new plans for the CES in Wilson's future. We decided that we would continue to work on the CES on our own and, at the same time, proceed with the on-going research projects with Wilson. We were analyzing their new golf balls and conducting a softball study examining some unique colors choices in addition to the traditional white.

Despite our disappointment of not having Wilson Sporting Goods as our ally in developing and marketing the CES, we continued to work on perfecting its performance. One of our challenges was to develop software so that the

CES learned how to respond to each individual during an exercise. The response to the person had to feel smooth without any sensation of jerkiness. I had spent much of my time and effort in trying to create the smooth feel that people exercising would want to experience. I knew from my own personal experiences that the feel of the movements had to be smooth because athletic and normal motions are also smooth, not jerky. The bar movement had to be free of any abrupt or jerky responses and I was determined to develop the CES accordingly.

At one time, we had a problem with bar movement at the top and the bottom of the range. During the transition from up to down, the bar seemed to move without resistance so that the bar felt like it was in a spongy gap of air. It was annoying to have this discontinuity in the smooth movement. We tried everything we could think of to correct the situation. Finally, Ann and I went to the university to discuss the situation with the professor of hydraulic engineering who had been so helpful previously. We described the behavior of the system and he immediately identified the problem as cavitation.

"You know, like the submarines," he explained. Of course, we did not know about submarines so the professor explained cavitation. Cavitation is the formation and then immediate implosion of cavities in a liquid. For example, small liquid-free zones or bubbles are the consequence of forces acting upon the liquid. It usually occurs when a liquid is subjected to rapid changes of pressure that cause the formation of cavities where the pressure is relatively low.

"Inertial cavitation" is the process where a void or bubble in a liquid rapidly collapses producing a shock wave. Inertial cavitation occurs in nature in the strikes of mantis shrimps, as well as in the vascular tissues of plants. In man-made objects, it can occur in control valves, pumps, and propellers.

Inertial cavitation was first studied by Lord Rayleigh, in the late 19th century, when he considered the collapse of a spherical void within a liquid. When a volume of liquid is subjected to a sufficiently low pressure, it may rupture and form a cavity. This phenomenon was coined "cavitation inception" and can occur behind the blade of a rapidly rotating propeller or on any surface vibrating in the liquid with sufficient amplitude and acceleration. A fast-flowing river can cause cavitation on rock surfaces particularly when there is a drop-off such as on a waterfall.

We were creating a vacuum within the hydraulic system. The professor explained that we could solve the problem by following Bernoulli's Principles. As far back as 1738, a Swiss scientist, Daniel Bernoulli, explained the principle of fluid dynamics. His principle states that an ideal liquid is affected by pressure and speed of flow. An increase in the speed of the fluid occurs simultaneously with a decrease in pressure or a decrease in the fluid's potential energy. The Bernoulli equation is a statement of the conservation of energy principle appropriate for flowing fluids. The qualitative behavior that is usually labeled with the term "Bernoulli Effect" is the lowering of fluid pressure in regions where the flow velocity is increased. This lowering of pressure in a constriction of a flow path may seem counterintuitive, but seems less so when you consider pressure to be energy density. In the high velocity flow through the constriction, kinetic energy must increase at the expense of pressure energy.

Ann and I returned to the laboratory and discussed the problem with Alan and Jeremy. As the professor had explained, we had to precisely calculate the sizes of all of the hydraulic tubing and the sizes of the check and spooler valves. In a steady flow, the sum of all forms of mechanical energy in a fluid along a streamline is the same at all points on that streamline. This requires that the sum of kinetic energy and potential energy remains constant. Thus, an increase in the speed of the fluid occurs proportionately with an increase in both its dynamic pressure and kinetic energy and a decrease in its static pressure and potential energy. If the fluid is flowing out of a reservoir, the sum of all forms of energy is the same on all streamlines because in a reservoir the energy per unit volume (the sum of pressure and gravitational potential) is the same everywhere.

Alan and Jeremy turned their attention to the calculations and within a week we were able to change the sizes of some of the hydraulic lines and the reservoir to adjust the hydraulic oil flow. After that, we had some minor corrections to perfect the feel but we had eliminated the unpleasant spongy sensation noted previously.

Another modification that we made was to change the shape and size of the spool valve into a triangular shape. This provided an increase in the control of the oil flow and, thus, improved the feel of the bar motion during exercise. Attention to the Bernoulli Principle has served us well for more than 30 years since no competitor has been able to reproduce the smoothness of our CES system.

Another significant development in the control of the CES came from a combination of my personal experience in the feel or perceived sensations of exercise as well as my studies at the university in the Cybernetics department. The head of the department was Dr. Michael Arbib who was renown in the field. His work follows the title of his first book, Brains, Machines and Mathematics. Dr. Arbib believed that the brain is not a computer in the current technological sense but we can learn much about machines from studying brains and much about brains from studying machines. I first heard him explain this concept in one of the classes that he taught. He presented a concept that an interdisciplinary environ-

NATIONAL FITNESS TRADE JOURNAL

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U.S. President Ronald Reagan exercising
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ment is one in which computer scientists and engineers can talk to neuroscientists and cognitive scientists.

In his class, he introduced his primary research focus on the coordination of perception and action. This was approached at two levels: (1) via schema theory which is applicable both in top-down analysis of brain function and human cognition as well as in studies of machine vision and robotics, and (2) through the detailed analysis of neural networks working closely with the experimental findings of neuroscientists in humans and monkeys. I was excited and enthralled with the concepts of studying the brain, its feedback loops of control, and the intelligence that machines could derive through, in my special application, computer-controlled programming.

"Cybernetics" is a trans-disciplinary approach for exploring regulatory systems, their structures, constraints, and possibilities. Cybernetics is relevant to the study of mechanical, physical, biological, cognitive, and social systems. It is only applicable when the system being analyzed is involved in a closed signal loop. In other words, when action by the system causes some change in its environment and that information is fed to the system via feedback which enables the system to change its behavior. Contemporary cybernetics began as an interdisciplinary study connecting the fields of control systems, electrical network theory, mechanical engineering, logic modeling, evolutionary biology and neuroscience in the 1940s.

Another contribution to the CES programming came from what was known as "Artificial Intelligence" (AI) which was founded as a distinct discipline at a 1956 conference. After some uneasy coexistence, AI gained funding and prominence. Consequently, cybernetic sciences, such the study of neural networks, were downplayed and the discipline shifted into the world of social sciences and therapy.

Artificial Intelligence (AI) is the intelligence of machines and the branch of computer science that aims to create it. AI textbooks defined the field as: "The study and design of intelligent agents" where an intelligent agent is a system that perceives its environment and takes actions that maximize its chances of success. John McCarthy, who coined the term in 1955, defines it as: "The science and engineering of making intelligent machines." My idea was that the computer software for the CES would be flexible in its ability to control the specific exercise, to adapt to the person performing the exercise, and to provide sufficient feedback control to the hydraulic system for a smooth motion.

Thus, my ideas for the CES were with feet in both camps of thought and study: cybernetics and artificial intelligence. The CES needed feedback just as the brain does in coordinating all human functions and intelligence to perceive and act on actions. While I attended classes and studied all the disciplines described, I had to create the correct applications from each theory in order for the CES to operate perfectly.

We continued our development and manufacturing of the CES with many of these concepts in mind. I met our first customer when I was demonstrating the Computerized Exercise System (CES) at the American College of Sports Medicine Conference. This was a sports science and physical therapy show in Montreal, Canada, in the spring of 1980. A young, knowledgeable physical therapist from New Jersey spent nearly an hour asking questions and trying the equipment. Then he inquired about the price.

"The price is $10,000," I answered wondering whether this was an astronomically high figure. Most fitness equipment was far less expensive while most of the physical therapy machines were extraordinarily pricey. I held my breath. The man reached into his pocket and pulled out a checkbook. He wrote ten thousand in the appropriate space, signed it, and handed it to me as he left the booth.

"Where do I ship it? Don't you want a receipt?" I called out to his receding back. The fellow turned and answered that the address was on the check and continued walking.

When I returned to Amherst after the conference, Ann was as surprised as I had been. "He didn't even fill the line of who to pay," she noted. "Who is this guy?" she asked.

The man's name was Robert Wainwright and his business was in northern New Jersey, not too far from New York City. Mr. Wainwright received Serial Number 1 of the CES and, shortly after the delivery, Ann and I traveled to visit him.

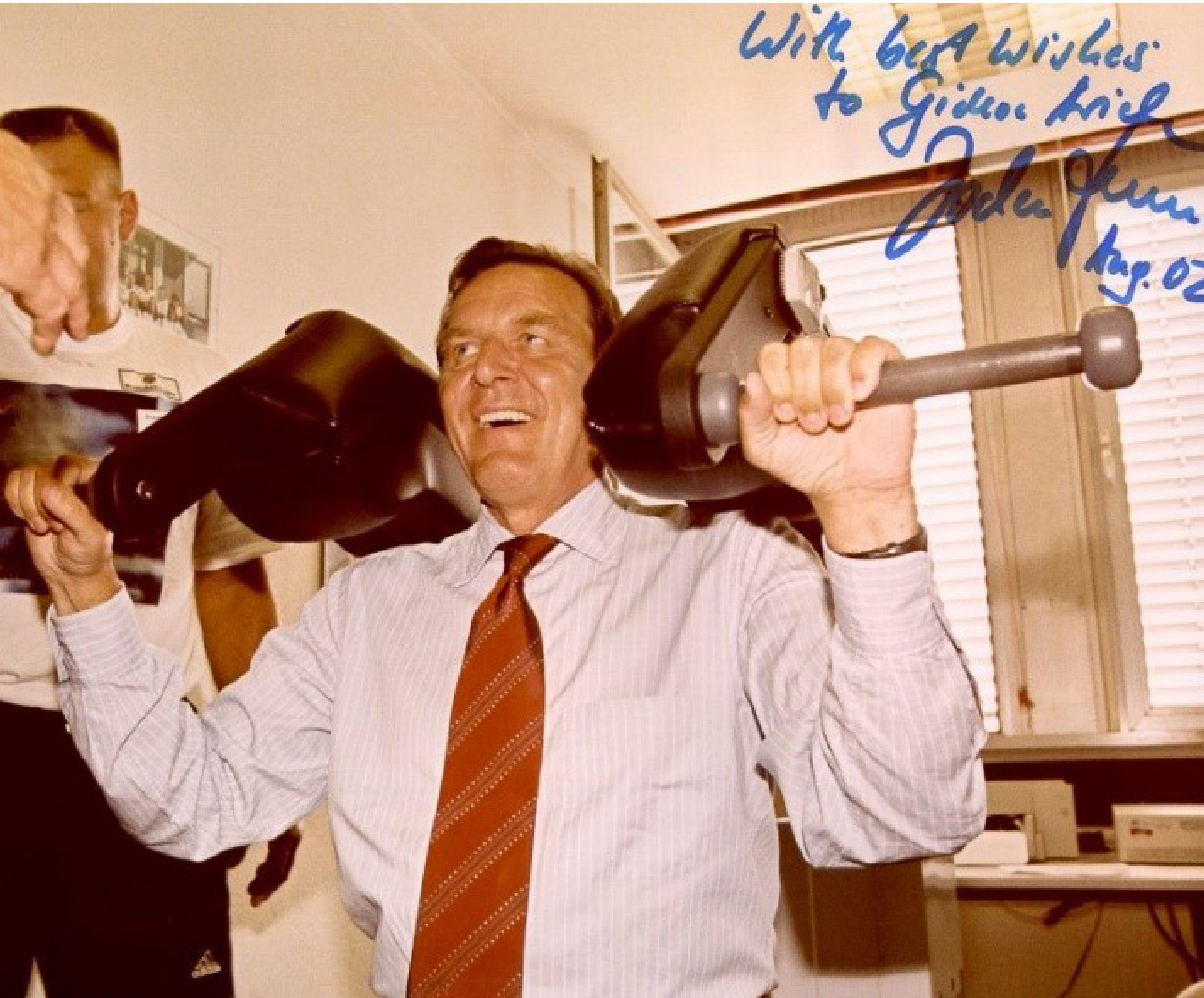
"Bob", as he insisted we call him, had a small physical therapy business. We drove down and spent the entire day working with him on the machine's capabilities in relation to his needs in the therapeutic environment. We demonstrated the ability to regulate the velocity of the bar in both pulling and pushing directions. Most of the equipment at that time was either a weight-bearing machine, which could not alter the velocity, or a closed system, which allowed only fixed velocity bar movements. We demonstrated how our computerized system permitted the therapist to program the velocity to follow any pattern he or she desired. The same programming flexibility was permitted with force. In other words, the therapist could decide about the amount of force that the patient needed to push, or pull, and could program the system to adhere to that pattern. These options of controlling velocity or force were particularly useful with patients recovering from injuries.

Mr. Wainwright told us that he frequently had athletes with knee injuries. They could not maintain a constant force or velocity since they needed the conditions to change throughout the exercise. They could move the bar easily with a reasonable load at the beginning of the exercise but when the action began to generate pain due to the injury, the system needed to respond by reducing the load. We demonstrated how he could control the entire range of the exercise motion. He could increase or decrease the load throughout the movement. Our equipment was the only system which could provide this control. It was the only one with a "brain" to program and capable of adjusting to the person as they were exercising.

From his point of view as a physical therapist, Mr. Wainwright was extremely pleased with these options. We also demonstrated how he could intensify the effort at a specific section of the movement by adding an isometric contraction at any location that he chose. This was very useful to him for strengthening certain muscles and another technique that was available only with our system.

We spent the entire day demonstrating the numerous exercise options available. Bob could now record and store each individual's workout and print results for the prescribing doctor and insurance company. In fact, for many years, Mr. Wainwright developed strong relationships with patients, hospitals, doctors, and insurance companies.

German Chancellor Schröder



We maintained a great relationship with Bob since those early days. He has been a colleague and dear friend for many years. We have worked and traveled with Bob around the world and cherish each of these memories.

In addition to the continuing development of the CES, I had many ideas for adapting and designing the CES for other purposes. For example, Ann and I were developing a prototype, drawer-sized CES for NASA to use on the Space Shuttle. This CES exercise device was developed to address two separate, but possibly related, issues. The first obvious consideration was to assist the astronauts in maintaining their muscular strength while on space missions in micro-gravity. One serious problem that astronauts encountered was the inability to walk and move about when they returned to Earth. Time was required to recover their muscular strength.

A second and possibly more serious problem was that the NASA astronauts suffered from osteoporosis during even short duration space missions. Osteoporosis is a very common disease affecting bone. It literally means "porous bones", and results in the loss of bone mass, rendering bones brittle and more susceptible to fractures. Here on Earth, this condition afflicts both men and women although it tends to be a problem that plagues more women than men. In addition, Earth-bound osteoporosis affects women more severely than men especially after menopause.

Exposure to the micro-gravitational environment of space causes astronauts to lose calcium from their bones. This loss occurs because the absence of Earth's gravity disrupts the process of bone maintenance in its major function of supporting body weight. Exercise creates forces that stimulate bone development. Bones are composite structures made up of bone matrix and mineral deposits that fill out the matrix.

It had been reported that astronauts in space could lose as much as two percent of bone mass per month which is several times more than is lost by patients with osteoporosis. Bone cell formation depends largely on the effects of weight through gravity and exercise. When weight is suppressed, bones undergo a process of demineralization accompanied by a loss of calcium to the blood.

Normally, the breakdown of old bone mass (resorption) and the formation of new bone mass (growth) occur constantly in a balanced cycle called "remodeling". Bone cells called osteoblasts make new bone and cells called osteoclasts break down old bone mass. In the weight-bearing parts of the skeleton, exposure to micro-gravity depresses the activity of bone-forming cells (osteoblasts) and may or may not stimulate bone-resorbing cells (osteoclasts). The remodeling process becomes unbalanced and the result is a localized loss of bone mass. Research also has shown that calcium is distributed differently throughout the skeleton in micro-gravity and in Earth-based space flight models.

Discoveries made in biomedical research on bones conducted in space are already contributing to a better understanding of osteoporosis and the treatment of bone mass loss on Earth as well as in space. The single most important contribution that NASA research has made to the understanding of bone deterioration in osteoporosis is the heightened awareness of the importance of gravity, activity, and biomechanics. In other words, there is a significant mechanical basis in the biological activity in bone remodeling.

Mechanical forces, that is, the action of energy on the matter, appear to coordinate bone-shaping processes. The standard theory of bone remodeling is that the body translates mechanical force into biochemical signals that drive the basic processes of bone formation. Aging, especially in post-menopausal women or for astronauts exposed to micro-gravity, uncouples bone destruction and formation. When this uncoupling occurs, formation lags behind the bone restoration and the result is bone loss.

Researchers are not yet certain whether bone resorption speeds up or the bone formation slows down although recent experimentation in space indicates that micro-gravity might somehow affect both processes. Progress in developing methods of preventing or treating disuse atrophy and osteoporosis depends on better understanding of the mechanisms that cause the problem. Determining how the body translates mechanical loading (physical stress or force) into the signals that control bone structure, may reveal how aging, inactivity, and space flight uncouple bone formation and resorption. Only in the absence of gravity can we more definitely determine the influence of weight and stress on bone dynamics.

By studying what mechanisms translates mechanical stress on bones into biochemical signals that stimulate bone formation and resorption, space life scientists may be able to determine how to maintain bone mass. Researchers do not yet know exactly what type and amount of exercise, hormones, or drugs might prevent bone loss or promote bone formation. Some combination of sex hormones and/or growth hormones and exercise seems to be the key to preventing bone mass loss associated with chronological aging and post-menopausal hormone changes on Earth.

We believed that the CES could be programmed to address this specific issue in micro-gravity. The CES had a "work" option which created an exercise requiring muscular effort to push up and pull down the bar. This exercise choice created a "weight" in micro-gravity because the computer control of the hydraulic system required muscular effort to move the bar. The physical effort would provide stimulus on the bony structures as well as the muscles because of the type of effort required to move the bar. We believed that the system would promote greater stress at the bone-muscle connections.

We envisioned that the feet could be held in shoes attached to the floor of the Space Shuttle. Then various exercises, for example a squat exercise, would require muscular forces which produced stress on the bones as well as strengthening the muscles. By generating stress in this manner, perhaps the body would have to replace rather than remove calcium from the bones. The goal would be to stimulate the development and replacement of the bones through exercise. We hoped that this would a better stimulus for healthy muscle-bone growth and development rather than having to rely on drugs.

Our hope was that the modified CES would assist in the prevention of space-induced osteoporosis. Furthermore, the proposed CES for the NASA shuttle missions could subsequently be adapted for hospital and home care use.

Our NASA contact and project administrator was Michael C. Greenisen. Dr. Greenisen was the manager of NASA's Exercise Countermeasures Project where he was responsible for the physiological functions of the astronaut crews for both the space shuttle missions and the International Space Station. NASA had also recently selected Dr. Greenisen as the Increment Scientist on a pending Space Station Expedition Flight. His experiences included work with the Russian Space Program and studies to determine effects of space flight on the skeletal muscle fibers. He was involved in the planning for the pending Mars missions. In 1996, NASA awarded Michael its Award of Merit for his work, "Formulating space medicine for human exploration of space."

As the head of biomechanics for NASA, Dr. Mike Greenisen expressed his satisfaction with the success of the program with NASA on the CES. He sent me the following letter expressing his appreciation.

> *Dear Dr. Ariel:*
>
> *Thank you for delivering the second generation Resistive Exercise Dynamometer RED. This is a remarkable design with the potential for an enormous positive impact on how astronauts exercise in space. The potential for modifying the RED such that it becomes a stair stepper or a rower is especially ingenious. Please extend my congratulations to Mr. Phill Harmon and his staff for a truly superb effort!*
>
> *In addition, the potential use of the RED as a dynamometer to measure skeletal muscle performance during space flight missions will be a major technological breakthrough. This option will provide NASA the capability to monitor skeletal muscle strength changes while on orbit. Knowledge of these changes will be a major enhancement that will enable appropriate space flight exercise countermeasures to maintain muscle performance.*
>
> *Sincerely,*
>
> *Michael C. Greenisen, Ph.D.*
>
> *Manager, Exercise Countermeasures Project*

The full CES system on the KC-135 Zero Gravity flights

In addition to our on-going work with NASA and with individual consumers, like Mr. Wainwright, we also began to hold clinics at our facility in California. The Coto Research Center was newer and larger than our Amherst office so it was convenient to have clinics there. We referred to these clinics as "user conferences" and they attracted people from around the world. We sold many CES to our Japanese distributor as well as many university research laboratories and physical therapy sites within the United States and beyond. Representatives from these facilities as well as potential buyers attended these clinics. The clinics provided opportunities for the people to learn more capabilities and operations of the CES system. In many cases, the interactions of these users with each other produced the most useful information for the attendees.

The CES had the ability to quantify movements, providing a new tool for research studies. Previously, research studies were relatively imprecise in their measurement capabilities. The precision and quantification provided by the CES were also useful for physical therapy treatments and testing. At that time, many physical therapy locations could test patients referred by doctors and insurance companies paid for the tests.

As I look back over the past nearly 40 years since the beginning of the CES, I experience a multitude of thoughts and emotions. I had an idea for an exercise machine. A machine that could adjust to me. I envisioned a device that could adjust the velocity or force of my exercise or add an isometric contraction at one or more points in the movement. I wanted the ability to save the data gathered during my exercise so that the information could be examined or processed during subsequent evaluation. The machine took on many additional features throughout the years and continued to be a better product with each addition or improvement. One of the most important lessons I learned during the thirty years of development was: when first imagining a future device it may seem like a simple concept to create, however, reality and life's experiences can easily overwhelm good ideas, and only perseverance can produce success.

A great idea can remain just that – a great idea. But to actually make that idea into a functional system is not as easy as the first flirtation with a concept. In the case of the CES, there were no small computers, spool valves, stepper motors, analog to digital converters, or software to tell the computer when and what to do. None of the components we ultimately needed were available until we either created our own, such as the "Blue Box" computer with its own hardwired boards and components, or discovered a part that someone or company had needed in an industry other than ours, such as the stepper motor. We usually had to develop our own component before we were able to find someone else who had a need and they had created a solution for themselves. That was how we discovered Mr. Dennis Kitz and his game port board to control his on-screen submarine. These fortuitous discoveries helped to develop the CES into the fantastic machine that it became. But, first, there had to be the idea, the desire for the widget that was needed, the successful integration of the parts, and the continuous development of the software to control the various interdependent components.

Fortunately, I had an idea and the tenacity to pursue it regardless of the many difficulties along the way. I found the best talent for each need from hydraulic engineers to software programmers. But perhaps my greatest strength, some might say my greatest weakness, is that I never, never, never quit until the problem has been solved completely.

Upon reflection, I was reminded of Thomas Edison's effort on what seems today to be a simple idea—the light bulb. From 1878 to 1880, Edison and his associates worked on at least three thousand different theories to develop an efficient incandescent lamp. Edison had to blow his own glass, find a filament that did not melt when electricity passed through it and that would maintain a soft orange glow, and would not blacken the inside of the glass bulb. I certainly am not trying to compare myself to Thomas Edison, but merely to convey the difficulties that ideas and inventions pose. There is a tremendous amount of work between an idea and its production. I was lucky to be in the right place, with the best people, and at the beginning of the computer revolution. With all of these components in place, the CES idea became a reality.

After nearly 4 decades, the CES is still unsurpassed in its abilities. No one and no company have ever successfully copied it or invented a device equal to it. It is still the best device of its kind and I take great pride in recognizing that it was my idea.